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# USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS

## MATERIALS SCIENCE AND METALLURGY

No. 50

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USSR

UDC 669.017

AN INVESTIGATION OF THE INTERPHASE DISTRIBUTION OF HYDROGEN IN ALUMINUM ALLOYS BY THE METHOD OF AUTO-RADIOGRAPHIC ANALYSIS

Ordzhonikidze TSVETNAYA METALLURGIYA in Russian No 4, 1977 pp 98-100  
submitted for publication 19 Apr 76

KRAVCHENKO, V. YE., KOLACHEV, B. A. and GABIDULLIN, R. M., Moscow Aviation Technology Institute, Department of Physical Metallurgy and Hot Treatment of Metals

[Abstract] The distribution of hydrogen in the structure of AL27-1 multi-phase aluminum alloy and binary alloys of aluminum with silicon, titanium and zirconium was studied by autoradiographic analysis using tritium as the activation agent. In hardened AL27-1 the hydrogen concentration in microcavities was substantially greater than in the solid solution, while in gas-shrinkage pores the concentration was greater in the boundary sections of the pore than at its center or in the solid solution. The high concentration of hydrogen in the solid solution adjacent to the pore boundary was explained by the fact that since tritium particle flow in air is almost nil, their flow through a pore is analogous, resulting in a concentration buildup at the pore's edge. Intermetallides (intermetallic compounds) which readily form when Ti or Zr are alloyed with aluminum dissolve hydrogen much better than the aluminum solid solution. As more Ti or Zr is added the hydrogen content in the intermetallides diminishes and the alloy can absorb more hydrogen. Also Ti and Zr reduce alloy porosity, yielding more volume for hydrogen absorption. Heat treating AL27-1 alloy, such as artificial aging at 250°C for two hours, results in partial degassing of the alloy with the remaining hydrogen redistributed between the phases and structural components primarily as segregations in the interphase boundaries of the intermetallides. Hydrogen segregation in the interphase boundaries has a significant effect on alloy behavior during plastic deformation and fracture. For an Al-8% Si alloy, hydrogen segregates in the eutectic component and is localized in the interphase boundaries. Hydrogen can be adsorbed on the surface of cracks and micro-defects inside the alloy, as was revealed by tritium activation which revealed cracks enriched with hydrogen. Figures 3; references 6: all Russian.

USSR

UDC 539.4

INVESTIGATION OF THE MECHANICAL PROPERTIES OF AN ALUMINUM ALLOY AND ITS  
WELD JOINTS IN PLANE STRESS AT LOW TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 104-111 manuscript  
received 10 Dec 75

BASHTA, V. V., GIGINYAK, F. F., LEBEDEV, A. A., NOVIKOV, N. V., SEMIROG-  
ORLIK, V. N. and SLIN'KO, V. P., Kiev

[Abstract] The principles of deformation and fracture of sheet material made from 1201 aluminum alloy and its weld joints were investigated where the alloy was subjected to conditions of uniaxial and uniform biaxial tension at temperatures ranging from 293 to 113°K. The features of processing the experimental data and conducting the tests by the method of swelling are shown. The source program, developed on a MIR-2 computer, for calculating swelling curvature and sheet thickness for a given pressure is listed. Results are given on the effect of the stress state form and temperature on the nature of alloy and weld joint strengthening. It was established that with a lowering of test temperature the form of the stress state affects the strain and strength properties of the weld joints but upon change from uniaxial to biaxial tension the ductility and strength properties of the base metal change very little. An analysis of the character of fracture of the tested samples is presented. Figures 9; references 8: all Russian.

USSR

UDC 620.178.322.3

ENDURANCE OF D16AT AND AMg6M THIN SHEET ALUMINUM ALLOYS IN LINEAR AND PLANE  
STRESS STATES UNDER HIGH FREQUENCY LOADING

Kiev PROBLEMY PROCHNOSTI in Russian No 9 (99), Sep 77 pp 55-57 manuscript  
received 29 Nov 76

STEFANOV, R. I., Kiev

[Abstract] A study is presented of the endurance of D16AT and AMg6M thin sheet aluminum alloys with various ratios of main stresses at high loading frequencies. The fatigue tests were performed on a magnetostriction resonant-type installation with high frequency oscillations of the point of attachment of the specimen, which was attached by a machine screw driven through a hole near an edge of the specimen. Circular plates and beams made of sheet materials 0.5 mm thick for D16AT and 0.8 mm thick for

AMg6M were tested. Oscillations were induced at 10.5 kHz. The endurance limits of the 2 alloys produced under these test conditions were found to depend on the ratio of mean stresses, with a decrease in endurance accompanying an increase in stress level. Figures 4; references 7: all Russian.

USSR

UDC 620.187:620.178.38:669.715:620.19

INFLUENCE OF LOW TEMPERATURES ON RATE AND MICROFRACTOGRAPHIC PECULIARITIES OF DEVELOPMENT OF A FATIGUE CRACK IN ALUMINUM ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKhanika MATERIALOV in Russian Vol 13, No 3, May/Jun 77 pp 26-30 manuscript received 30 Sep 76

OSTASH, O. P., YAREMA, S. YA., and STEPANENKO, V. A., Institute of Physico-Mechanics, Academy of Sciences Ukr SSR; Institute of Strength Problems, Academy of Sciences Ukr SSR

[Abstract] Results are presented from electron fractographic studies of specimens of the D16AT and V95AT1 alloys, fractured under cyclic loading at temperatures of 20°C and -160°C. An attempt was made to separate the influence of temperature into two components: that resulting from the change in properties of the material and that resulting from the change in the interaction of the material with its environment. It is shown that each of the three sectors of the kinetic fatigue fracture diagram of the alloys corresponds to a certain typical microrelief of the fracture, the nature of which does not change essentially as the temperature is lowered to -160°C. Curves of the temperature variation of crack growth rate show a break at a temperature near -70°C, caused by the decrease in content of water vapor in the air to below a critical level at this temperature. References 19: 8 Russian, 11 Western.

USSR

UDC 669.71'72:621.785.78

STUDY OF THE INITIAL STAGE OF DECOMPOSITION IN AN ALUMINUM-MAGNESIUM ALLOY

Moscow FIZIKA METALLOV I METALLOVEDENIYA in Russian Vol 43, No 6, Jun 77 pp 1228-1234 manuscript received 14 Apr 76

DOBROMYSLOV, A. V., KAYGORODOVA, L. I. and KOMAROVA, M. F., Institute of Metal Physics, Academy of Sciences USSR

[Abstract] The method of diffuse scattering of x-rays is used to study the structure of Al-Mg alloys, specimens of which had been held for many years

at room temperature. Diffuse scattering is detected which indicates that decomposition in the Al-Mg alloy occurs similarly to decomposition in other aluminum alloys, such as those with silver, zinc and magnesium, with the formation of spherical particles in the initial stage of decomposition. This should be followed by formation of the  $\beta'$  phase, then finally the  $\beta$  phase. References 16: 8 Russian, 8 Western.



USSR

UDC 629.7.015.4.023.8

INCREASING THE SERVICE LIFE OF SHEET SAMPLES BY USING COMPOSITE COATINGS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 118-120 manuscript received 1 Jun 76

KARLASHOV, A. V., BELETSKIY, V. M., KRIVOV, G. A., GNATYUK, A. D., YUDINA, S. A., D'YACHENKO, YU. N. and KONOVALOVA, N. A., Kiev, Moscow

[Abstract] D16AT alloy sheet (1.2 mm thick) was coated with KAS-1 metallic composite to determine if composite coatings should improve the service life of sheet materials. KAS-1 consists of VNS-9 steel wire (0.15 mm in diameter) in a matrix of AD1 aluminum alloy and is produced by hot pack rolling in a vacuum. The D16AT samples had fatigue cracks 2--3 mm long and were separated into six groups. Group I was coated with the composite by glue welding using K-4S glue. Group II was coated using VK-9 glue over a sublayer of VK-32-200 glue while group III employed K-4S to join the composite coating. Groups IV and V used the same glues as II and III except that the coating was OT4 titanium alloy. Group VI had no coating. Fatigue tests showed that the resistance to fatigue failure of the groups was ranked in the order of the groups--group I the best, group VI the poorest. This was explained by two factors: 1) the low tendency of the composite material to transfer and form cracks due to the large number of contact areas, and 2) the toughness of the glue welded coating, which led to redistribution of the load. Figures 3; references 1 Russian.

USSR

UDC 546.26:541.66

THERMAL EXPANSION OF CARBON-CARBON COMPOSITE MATERIALS

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian Vol 13, No 8, Aug 77 pp 1429-1433 manuscript received 22 Apr 76

LUKINA, E. YU., KOLESNIKOV, S. A., and PECHIK, V. K.

[Abstract] This work presents the results of a study of the thermal expansion of composite materials based on carbon fibers with various types of binder. Several methods were used to measure the thermal expansion: up to 1000°C, the coefficient of thermal expansion was measured on a vertical quartz dilatometer, with temperature determined by chromel-alumel thermocouples. From there to 2500°C, the CTE was determined by an absolute method by directly measuring the elongation of the specimens with an MG-1 comparator, the temperature with an EOP-66 optical pyrometer. Carbon-carbon composites have high anisotropy of thermal expansion, which is determined in the direction of the fiber primarily by the thermal expansion of the fiber, in the transverse direction by the expansion of the binder. Pyrocarbon is closest to the fiber as to thermal expansion. Carbon fibers and composites irreversibly changed their dimensions when heated to above the temperature at which they were produced. The CTE of dispersed-fiber based composites increases with increasing binder density, the anisotropy decreasing. References 3: all Russian.

USSR

UDC 678.067.5

CONDITIONS OF CONTINUITY OF FRP COMPOSITES

Riga MEKHANIKA POLIMEROV in Russian No 3, May/Jun 77 pp 540-542 manuscript received 19 Jul 76

ROGINSKIY, S. L., All-Union Scientific Research Institute for Fiberglass-Reinforced Plastics and Glass Fibers, Moscow

[Abstract] A study is made of a 5-layer model of a composite consisting of three unidirectional reinforced layers and two interlayers of binder between them. The middle layer is loaded with an axial compressive stress; the two outer layers receive the load through the binder. The reinforcement of each successive reinforced layer is rotated by 90° with respect to the previous layer. A system of differential-difference equations is used to analyze the stress-strain state of the model selected. An equation is produced to determine the minimum permissible adhesive strength. The conditions of continuity, a system of four equations,

allow requirements for the binder to be formulated on the basis of the physical and mechanical properties of the reinforcing filler. A single equation is presented for the condition of strength of orthogonally reinforced FRP, considering dispersion of the properties of the components, the required reliability and the influence of environmental factors. References 7: all Russian.

USSR

UDC 678.067.5.001

#### SECONDARY STRESSES RELATED TO THE STRUCTURE OF A COMPOSITE MATERIAL

Riga MEKHANIKA POLIMEROV in Russian No 3, May/Jun 77 pp 452-457 manuscript received 30 Jul 76

KORNEV, V. M., Institute of Hydrodynamics, Siberian Affiliate of the Academy of Sciences USSR, Novosibirsk

[Abstract] A study is made of a complaint flat matrix reinforced with a system of infinitely thin fibers of finite rigidity. The model selected is close to reality if  $F_1/ha \ll 1$ , where  $F_1$  is the cross-sectional area of the fibers and  $h$  is the thickness of the matrix, as in a thin wall tubular specimen with longitudinal reinforcement. Secondary stresses are determined and analyzed. The secondary stress-strain state is divided into two basically different elements -- a rapidly oscillating component in the direction of the strip and edge effects near the edges, the rate of damping of which is determined by parameters characterizing the orthotropy and frequency of placement of the threads. References 11: 10 Russian, 1 Western.

USSR

UDC 620.172.251.224

#### EFFECT OF REINFORCING ALLOY AD1 WITH BORON AND SILICON CARBIDE FIBER ON ITS STRENGTH AT ELEVATED TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 112-114 manuscript received 28 Oct 75

MAKSIMOVICH, G. G., KARPINOS, D. M., LYUTYY, YE. M., KADYROV, V. KH. MOROZ, V. P. and FILIPOVSKIY, A. V., Institute of Physico-Mechanics, Academy of Sciences Ukrainian SSR and Institute of Polymer Mechanics, Academy of Sciences Ukrainian SSR

[Abstract] The effect of temperature on the strength, ductility and nature of fracture was investigated for a composite having a ductile matrix

material (AD1 alloy) and brittle reinforcing fibers (boron and silicon carbide). Composites consisting of AD1 alloy with 33 and 46% (by volume) boron and 33 and 46% SiC fibers were tested and in all instances the composite containing boron possessed the best strength, ductility and coefficient of strengthening and retained these properties at a high level at elevated temperatures (up to 400°C). The nature of fracture for these composites was brittle with cracks occurring initially in the fiber material, primarily in the tungsten threads of the fiber, with crack direction perpendicular to the acting load. Cracks were also found in the direction of the applied load with cracks in both directions caused by pores and inclusions. If one crack forms at room temperature in the matrix and cuts the fiber in half, then at elevated temperatures the number of cracks will increase and propagate radially to the fiber center, splitting it into individual segments. By comparison, the reinforced AD1 alloy had a much higher specific strength than V95T, D16T, Amg6 and SAP-1 alloys. Figures 5; references 8: 4 Russian, 4 Western.

USSR

UDC 621.771:660.71

OPTIMIZING THE APPARATUS DESIGN AND THE PROCESS PARAMETERS FOR INVERTED HOT MOLDING OF TUBES FROM COMPOSITE MATERIALS WITH BRITTLE FIBER REINFORCEMENT

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul/Aug 77  
pp 144-149 manuscript received 15 Mar 77

MANUYLOV, V. F., MAKAROVA, S. A., SHORSHOROV, M. KH., KOLPASHNIKOV, A. I.,  
and TIKHONOV, A. S.

[Abstract] The method of inverted hot molding is extended to making tubes from an aluminum-boron composite with a brittle fiber reinforcement oriented parallel to the axis. The three main requirements are that the finished product be adequately compact, that no fiber breakage occur, and that the forming (pressure application) time not exceed the time necessary for fiber-to-matrix interlinkage, i.e., the surface activation time. On the basis of relations derived accordingly between the tube dimensions and the apparatus geometry, with the fundamental relations for the process parameters (total molding pressure and linear molding rate), an optimum design is arrived at for tubes with the outside diameter ranging from 40 to 60 mm and the wall thickness ranging from 1.0 to 2.0 mm. Prototype tubes thus produced had an axial (tensile) strength of 95-100 kgf/mm<sup>2</sup> with 0.41% vol. fiber reinforcement and 115-125 kgf/mm<sup>2</sup> with a 0.5% vol. fiber reinforcement; their radial (compressive) strength was 8-10 kgf/mm<sup>2</sup>, i.e., higher than the strength of the bond between the aluminum-boron matrix and the reinforcing fibers. Figures 2; references 4: all Russian.

USSR

UDC 621.9-419.620.17:539.3

# STUDY OF INHIBITION OF CRACK GROWTH IN MULTILAYER METAL COMPOSITES

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 3, May/Jun 77 pp 3-11 manuscript received 31 May 76

KUDRYAVTSEV, B. A., PARTON, V. Z., SOKOVIKOV, A. M., and TANANOV, A. I., Moscow Institute of Chemical Machine Building

[Abstract] Results are presented from an experimental study of the nature of stopping of the growth of a crack in sheet bimetals such as Type 3 steel + Kh18N10T steel and silicon iron + Kh18N10T steel under various loading conditions, and the possibility of inhibition of crack growth as cracks reach the boundary separating the layers of the bimetal is theoretically analyzed. The experiments were performed on machines allowing direct observation of the movement of the fracture crack and the determination of the moment when it stopped as it reached the transition zone of the bimetal. The studies were performed in the temperature range from  $-196^{\circ}\text{C}$  to  $+1,000^{\circ}\text{C}$  under static and cyclic loading. Cracks were analyzed using a scanning electron microscope. It was found that the delay in the fracture of multilayer clad composites results both from the barrier effect of the division boundary between layers and from the plastic relaxation at the tip of the main fracture crack as it enters the clad layer. The presence of structural and strength heterogeneity in the transition zone of the bimetal has a significant influence on the process of slowing of the crack. In three-layer composites with a crack in the base metal, the presence of the supporting clad layer increases the critical load as the crack approaches the layer division surface. Effective selection of the parameters of the reinforcing clad layers can assure stable crack growth as the crack reaches the division boundary of the bimetal layers. References 10: 8 Russian, 2 Western.

USSR

UDC 539.4:669.71

# DEPENDENCE OF THE TENSILE STRENGTH ON THE REINFORCEMENT ANGLE IN COMPOSITES OF ALUMINUM ALLOY WITH STEEL WIRE

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 7, Jul/Aug 77 pp 133-136 manuscript received 9 Jan 77

SHORSHOROV, M. KH., USTINOV, L. M., and ZHAMNOVA, V. I., Moscow

[Abstract] A study was made to determine how the strength of a composite consisting of aluminum alloy with steel wire reinforcement is influenced

by the angle of tension relative to the reinforcement orientation. The test specimens were made of a Zn-Mg aluminum alloy reinforced with wire of grade EP322 steel (14% of total volume). In one batch a 15-20  $\mu\text{m}$  thick brittle aluminum-iron interlayer was also intentionally built up by proper annealing. The specimens were tested on an "Instron" machine. As the tension angle is increased from 0 to 90°, the strength without an intermetallic interlayer remains at its initial 69  $\text{kgf/mm}^2$  until the angle exceeds the critical 15°, whereupon it decreases to 36  $\text{kgf/mm}^2$  at 45°, then it again increases slightly to 43  $\text{kgf/mm}^2$  at 70°, and continues decreasing to 37  $\text{kgf/mm}^2$  at 90°. With an intermetallic interlayer, the strength begins to decrease at 7° and, while following the same trend, remains consistently 11-15  $\text{kgf/mm}^2$  lower. Figures 1; references 7: 2 Russian, 5 Western.

USSR

UDC 669.295.5'71.28.292:620.193

INFLUENCE OF SALT CORROSION ON LONG-TERM STRENGTH OF PSEUDOALPHA TITANIUM ALLOYS

L'vov FIZIKO-KHIMICHESKAYA MEKhanika MATERIALOV in Russian Vol 13, No 4, Jul/Aug 77 pp 45-48 manuscript received 12 Feb 76

KOLACHEV, B. A., TRAVKIN, V. V. and ARTSYBASOV, YU. N., Moscow Aviation Technology Institute

[Abstract] A study is presented of the influence of salt corrosion on the long-term strength of pseudoalpha titanium alloys, and a metallographic study of the fracture zone is performed. The experiments are performed at 350-500°C using the OT4-1, OT-4 and VT-20 alloys. Specimens with a gage section width of 10 mm and length 55 mm were cut from a 1.5-mm sheet in the transverse direction. Specimens of VT-20 alloy were subjected to both simple and vacuum annealing at 750°C for 1 hour. OT4-1 and OT-4 alloys were tested as delivered and after 2 hours annealing in a vacuum at 670°C. The experiment showed that OT4-1 is most resistant to salt corrosion and VT-20 the least resistant. This result corresponds to the general tendency of increased salt corrosion of titanium alloys with increasing aluminum content. Vacuum annealing decreases the resistance of pseudoalpha alloys to salt corrosion. Stress concentrators (notch radius 0.1 mm) have no significant influence on the formation and growth of cracks in OT-4 alloy with salt corrosion. Salt corrosion, however, significantly decreases the fatigue strength of OT-4 alloy. Figures 3; references 3: 2 Russian, 1 Western.

USSR

UDC 620.193.43

THE CORROSION OF REFRACTORY BORIDES IN FUSED SODIUM

Moscow ZASHCHITA METALLOV in Russian Vol 13, No 5, Sep/Oct 77 pp 589-591 manuscript received 3 Apr 75

ARABEY, B. G., GLUKHOV, V. A. and MARKOV, YU. M., All-Union Scientific Research Institute for Aviation Materials

[Abstract] The diborides of chromium, tantalum, and hafnium, the hexaborides of samarium, gadolinium, and europium and composites of europium hexaboride with the diborides of the metals listed above were subjected to corrosion in fused sodium. After corrosion, the specimens were weighed and measured, and prepared sections were used in inspecting the structure. The relative corrosion resistance of a boride in sodium was characterized by an arbitrary boron conversion factor, equal to the ratio of the quantity

of boron dissolved per unit of visible surface area to the percent content of boron in the specimen. Diborides are quite resistant in contact with sodium right up to 800°C, after which corrosion increases significantly. The hexaborides of samarium, europium and gadolinium interact with sodium beginning at 600°C, compact specimens of these compounds dissolving completely at 800°C in 1500 hours. Alloying of europium hexaboride with the diborides of chromium, hafnium and tantalum causes an increase in corrosion resistance of the composite produced. Life at 800°C is over 5,000 hours. No sodium borates were found in the study. The sodium is assumed to penetrate by capillary action, followed by diffusion along grain boundaries, reaching great depths in the specimens. Figures 2; references 3: 1 Russian, 2 Western.

USSR

UDC 620.194

INFLUENCE OF PLASMA ATOMIZATION ON FATIGUE STRENGTH OF TYPE 30KhGSA STEEL UNDER FRETTING CORROSION CONDITIONS

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 4, Jul/Aug 77 pp 54-57 manuscript received 23 Mar 76

ALYAB'YEV, A. YA., SHEVELYA, V. V., VENEDIKTOV, V. A., and CHAYKA, B. I., Kiev Institute of Civil Aviation Engineering

[Abstract] The method of plasma deposition of wear-resistant coatings was used to increase the endurance of parts operating under fretting corrosion conditions. Fretting corrosion was produced by seating sleeves of the same material on cylinder specimens of 30KhGSA steel and tightening a collar to produce a specific load of 6-7 kg/mm<sup>2</sup>. Fretting corrosion developed beneath the sleeves upon cyclical deformation of the specimens at 50 Hz. Specimens were used without preliminary working, after shot peening and after plasma deposition of the U10A, 4Kh13, 11Kh18MVD materials, which consist of pearlite plus carbide, martensite and ferrite with chromium carbide inclusions, respectively. The results indicate that shot peening provides a strong bond of the atomized coating with the surface of the substrate and, due to surface strain hardening, has a positive influence on the endurance of 30KhGSA steel both against fretting corrosion and against ordinary fatigue. The most effective of the three coatings is 4Kh13, the martensitic coating. Plasma atomization of this coating is almost equal to galvanic chrome plating in its wear resistance during fretting corrosion, and significantly increases endurance and durability. It can be recommended to replace chrome plating in the production and repair of machine parts. Figures 4; references 3: all Russian.



FATIGUE AND CORROSION-FATIGUE STRENGTH OF SHEET MATERIALS MADE OF D16  
AND AK4-1 ALLOYS

L'vov FIZIKO-KHIMICHESKAYA MEKhanika MATERIALOV in Russian Vol 13, No 4,  
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KARLASHOV, A. V., VIGDORCHIK, S. A., GAYNUTDINOV, R. G., PANKOV, A. T., and  
BAYSHUMUROV, ZH., Kiev Institute of Civil Aviation Engineering; Moscow  
Machine Building Plant

[Abstract] The maximum thickness of a cladding layer permitting maximum fatigue and corrosion-fatigue durability can be established as 25-30  $\mu\text{m}$ . Therefore, materials were selected with cladding layer thicknesses of 0-30  $\mu\text{m}$ , plus materials with no coating and materials of D16 alloy and AK4-1 alloy 2 mm thick with the normal thickness of cladding layer (52-80  $\mu\text{m}$  for the former, 65-75  $\mu\text{m}$  for the latter). Thickness of the cladding layer had little effect on endurance of the materials in air, but in corrosive environments, the materials with thinner cladding layers showed higher fatigue strength (endurance) than materials with the "normal" thick cladding layers. Figures 2; references 6: all Russian.

USSR

UDC 539.411:620.173.22:666.1

RESISTANCE OF GLASS AND SITALS TO DEFORMATION AND FRACTURE UNDER  
CONDITIONS OF BIAXIAL COMPRESSION

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 89-95 manuscript  
received 20 Oct 76

PISARENKO, G. S., OKHRIMENKO, G. M. and RODICHEV, YU. M., Institute of  
Strength Problems, Academy of Sciences Ukrainian SSR

[Abstract] STL-10, A-1, A-3, V and Sitals and 13v and S49-2 glasses were tested for their resistance to deformation and fracture under biaxial compression. The distribution of probabilities of maximum strength for sitals and glass was found to be independent of sampling volume, while stress state, conditions at the sample ends and chemical composition of the material as well as the state of the side surfaces can be satisfactorily described by the normal law. In evaluating the limiting condition of glass and sital parts working under compression, it is necessary to consider the degree of surface damage caused by the technological modes and conditions of part operation. For practical calculations of design elements, performing under conditions of plane stress, the theory of the greatest normal stresses should be used. Unfavorable boundary conditions in the loading of glass and sitals can lead to incorrect establishment of the characteristics of strength and maximum condition of failure and, consequently, to ineffective use of the given materials. The authors thank A. A. LEBEDEV and A. P. POLESHKO for their help in this study. Figures 5; references 12: all Russian.

USSR

UDC 678:539.42

ON THE METHODOLOGY OF DETERMINATION OF FRACTURE TOUGHNESS OF ORGANIC GLASS

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 4,  
Jul/Aug 77 pp 32-34 manuscript received 22 Jul 76

FINOGENOV, G. N., PANSIN, B. I. and KULAKOV, G. P., All-Union Institute  
of Aviation Materials, Moscow

[Abstract] A standard has been developed for determining the fracture toughness of metal materials. This article attempts to apply and refine the standard for polymethylmethacrylate glass. Stress-strain diagrams were produced using a type UM-5 universal tensile testing machine with a deformation rate of the specimens of 10 mm/min using a sensor which showed the relative displacement of 2 fixed points on the specimen with a separation of 6 mm on the edges of a notch. The studies indicated that the

standard developed for metals can be used to describe the fracture toughness and determine the stress intensity factor of organic glass and similar polymer materials as long as plane strain conditions are maintained. Figures 2; references 4: 2 Russian, 2 Western.

USSR

UDC 669.295:620.186.5 -- 172

THE EFFECT OF HEAT TREATMENT CONDITIONS ON THE FORMATION OF LAMINATE  
TITANIUM MONOCRYSTALS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 3, 1977  
pp 649-652 manuscript received 10 Mar 76

KURMAYEVA, L. D., SMIRNOV, L. V., and FOKINA, YE. A., Institute of  
Physics of Metals, Ural Scientific Center, Academy of Sciences USSR

[Abstract] A study was made of conditions that assure the maximum development of grains in the area where beta-phase crystals exist, i.e., the production of these single crystals and their transformation into alpha-monocrystals, without prolonged treatment at 850°C. Titanium iodide bars 10 mm in diameter were rolled into sheets 7 mm thick with 93 percent deformation, then annealed after chemical polishing in a  $10^{-5}$  mm Hg vacuum. Other titanium specimens were annealed at 700° for one hour, then heat-treated up to 1100°, held at that temperature for 3 hours, and cooled at room temperature. This cycle was repeated three times; as a result either single crystals or bicrystals formed. Examination with an electron microscope showed that in the beta → alpha transformation the beta crystals need not break down into several alpha crystals. Thermal cycles of other durations showed that with 2-hour heat treating, single crystals formed, but 1 hour treatment did not result in the transformation. Constant annealing in the beta-phase did not assure the necessary conditions for crystallization. Variants of the procedure were heating at 300°/hour to 1100°, holding that heat for 2 hours, and cooling, and rapid heating followed by the other steps of the procedure. In these tests the macrostructure was more pronounced in the first, and a small-grain structure in the second. Figures 2; references 13: 9 Russian, 4 Western.

USSR

UDC 539.385:669.721.017

KINETICS AND MECHANISM OF FATIGUE FAILURE IN MA2-1 AND MA12 MAGNESIUM ALLOYS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 40-45 manuscript received 20 Apr 76

GRINBERG, N. M., SERDYUK, V. A., YAKOVENKO, L. F., MALINKINA, T. I. and KAMYSHKOV, A. S., Physico-Technical Institute of Low Temperature, Academy of Sciences Ukrainian SSR, Khar'kov

[Abstract] Two magnesium alloys--MA2-1 (4.17% Al, 0.85% Zn and 0.5% Mn), annealed at 250°C for one hour, and MA12 (2.9% Nd and 0.44% Zr), quenched after heating at 540°C for two hours and aged 200°C for 16 hours--were subjected to symmetrical cyclic loads in order to study their fatigue failure mechanism and kinetics. Resulting grain diameters from the heat treatments were 12 microns for MA2-1 and 80 microns for MA12. Fatigue failure occurred by different mechanisms, independent of stress amplitude, in the upper portion of the fatigue curves: an H-mechanism for MA2-1 and an F-mechanism for MA12. Fatigue in MA2-1 alloy occurs without development of stable slip bands by means of crack nucleation and growth perpendicular to the applied stresses. Cracking starts much sooner in MA12 alloy and develops by formation of stable slip bands with nucleation and growth of microcracks in stage I, subsequent microcrack propagation in stage II at a fast rate and the joining of the stable slip bands, being formed in the zone of microcracking, with final merging in the mainline crack. Figures 5; references 10: 4 Russian, 6 Western.

USSR

UDC 621.791.011

MECHANICAL PROPERTIES OF WELDS OF 01420 ALUMINUM ALLOY WHEN WELDING WITH A TUNGSTEN ELECTRODE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 6, 1977 pp 56-58 manuscript received 8 Sep 76

ISHCHENKO, A. YA., Candidate of Technical Sciences, and CHAYUN, A. G., engineer, Ukrainian SSR Academy of Sciences, Institute of Electric Welding imeni Ye. O. Paton, and BELETSKIY, V. M., Candidate of Technical Sciences, and BELYAYEV, V. N., engineer, Kiev Aviation Plant

[Abstract] It is possible to reduce porosity considerably and increase ultimate strength by protecting the back bead with argon and using an admixture of AMg6Tsvch alloy in argon arc welding of 01420 alloy (aluminum-magnesium, lithium), using alternating current. This paper gives the results of studies conducted to improve fusion welding technology and to increase the functional properties of joints of this alloy. A comparison is made between the advantages of new highly productive methods of welding employing asymmetric alternating current and forward polarity direct current and welding employing the usual alternating current. An OARS-4 asymmetric alternating current power supply made it possible to vary the ratio between forward and reversed polarity currents over a wide range. The different ways the metal melts when using different methods of welding are illustrated by photos of butt joints from the face side and of the macrostructure of welds. Photos are shown for argon arc welding with asymmetric current and for argon arc welding with alternating current, for welding in helium with forward polarity direct current, and for argon arc welding employing reversed polarity direct current. A table is presented which shows the relationship between welding conditions and the mechanical properties and porosity of joints. It was found that welds made using asymmetric alternating current are tight and have the highest ultimate breaking strength, bending strength and impact strength. It is concluded that the use of asymmetric alternating current and protection of the back bead with the argon when welding thin sheets of 01420 alloy in the artificially aged state make it possible to obtain joints with an ultimate breaking strength of 38 to 39 kg/mm<sup>2</sup>, which amounts to at least 80 percent of the strength of the base metal. Welding 01420 alloy using forward or reversed polarity direct current has no advantage over ordinary argon arc welding employing alternating current, since porosity of the weld metal is increased and the strength of joints is reduced. Figures 2; references 4: all Russian.

USSR

UDC 669.715:539.56

ON THE RELATIONSHIP OF DUCTILE FRACTURE OF SEMIFINISHED PRODUCTS MADE FROM ALUMINUM ALLOYS TO MECHANICAL PROPERTIES

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 65-68 manuscript received 14 Jun 76

TELESHOV, V. V. and KUDRYASHOV, V. G., All-Union Institute of Light Alloys, Moscow

[Abstract] Semifinished products made from V93, V95 and V96ts aluminum alloys were used to check the possibility of using published empirical relationships to predict ductile fracture ( $K_{IC}$ ) as a function of tensile strength (TS) and yield strength (YS). No simple link was found between  $K_{IC}$  and TS or YS; however, the authors developed their own method using multiple regression which yielded accurate quantitative results as long as mutually independent mechanical properties such as TS and relative elongation ( $\epsilon$ ) were used to obtain equations of the form:  $K_{IC} = a_0 + a_1 TS + a_2 \epsilon$ . The aluminum alloys were tested in the longitudinal and vertical directions and the above equation was solved by the method of least squares, from which the following equation was derived:  $K_{IC} = 120.1 - 1.18 TS + 5.14 \epsilon$ , which had a residual dispersion of  $s^2 = 148$  for 32 degrees of freedom. Data for the longitudinal direction gave:  $K_{IC} = 154.5 - 1.45 TS + 3.12 \epsilon$  with  $s^2 = 161$  for 15 degrees of freedom. The shortcoming of this method of determining ductile fracture is that it can be applied only to the materials used to derive the equations. Continued study is required to find a universal relationship of ductile fracture to easily determined mechanical properties. Figures 3; references 11: 6 Russian, 5 Western.

USSR

UDC 620.172.254

MECHANICAL PROPERTIES OF CERTAIN METALS IN SHOCK TENSION IN THE 20-500°C TEMPERATURE RANGE

Kiev PROBLEMY PROCHNOSTI in Russian No 9(99), Sep 77 pp 97-99 manuscript received 8 Feb 77

VASHCHENKO, A. P., Institute of Strength Problems, Academy of Sciences Ukr SSR

[Abstract] This work presents the results of mechanical testing of armco iron and D16 aluminum alloy in extension at deformation rates of  $V$  of

2-2.5 mm/min to 70/80 m/s, corresponding to deformation rates  $\dot{\epsilon}$  of up to  $10^4 \text{ s}^{-1}$  in the 20-500°C temperature range. Dynamic testing at various temperatures was performed using a vertical drop hammer and a pneumatic-powder hammer, static testing on a hydraulic press produced by the Baldwin Southwark Company. The results of testing of D16 alloy indicate that as it is heated up to 350°C at all of the deformation rates tested the strength decreases, while ductility increases, the plasticity characteristics increasing significantly more rapidly with static testing than with dynamic testing. As the temperature rises, the sensitivity of the alloy to deformation rate increases. The strength characteristics of armco iron decreases smoothly over the temperature interval tested only when tested at approximately 75 m/s loading rate. Under static testing conditions, as temperature rises to 100°C the mechanical properties remain almost unchanged; there is an increase in tensile strength between 100 and 200°C with a simultaneous decrease in relative elongation and reduction in area. Figures 3; references 9: 8 Russian, 1 Western.

USSR

UDC 621.793.14:669.181

# STUDY OF THE STRUCTURE AND MECHANICAL PROPERTIES OF THICK DISPERSION-HARDENED NICKEL-ZIRCONIUM DIOXIDE CONDENSATES

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 77 pp 52-57 manuscript received 30 Apr 76

MOVCHAN, B. A., DEMCHISHIN, A. V., and BADILENKO, G. F., Institute of Electric Welding imeni Ye. O. Paton

[Abstract] A study was made of the influence of substrate temperature and quantity of the second phase on the density, hardness and short-term mechanical properties of nickel-zirconium dioxide condensed material. Experimental values of flow stresses were also compared with calculated values, based on the dislocation model of Orowan modified by Ashby. Primary attention was given to the concentration dependence of standard yield points of polycrystalline Ni-ZrO<sub>2</sub> condensates. The variation of mechanical properties with content of the second phase agreed with today's concept of the significance of dispersion and quantity of particles in dispersion-hardened materials. For all particle sizes, yield point increases greatly in the area of low concentration of ZrO<sub>2</sub>. As the content of zirconium dioxide is further increased, the yield point increases only slightly. This results from one peculiarity of the concentration dependence of the distance between particles in condensates, which decreases with slight addition of ZrO<sub>2</sub>; then remains practically constant as ZrO<sub>2</sub> concentration increases. Figures 5; references 10: 5 Russian, 5 Western.



USSR

UDC 536.1001.57:539.217

INFLUENCE OF MANUFACTURING TECHNOLOGY ON THE STRUCTURE AND DELAMINATION  
TENDENCY OF THORIATED TUNGSTEN

Kiev POROSHKOVAYA METALLURGIYA in Russian No 9 (177), Sep 77 pp 44-49  
manuscript received 25 Mar 75

KORCHAGIN, I. V., KESAYEV, T. M., DZUTSEV, A. N., NATAPOV, B. S. and  
TSVETKOVA, A. KH., "Pobedit" Plant, Ordzhonikidze; Zaporog Machine-  
Building Institute

[Abstract] To determine the possibility of producing more highly dispersed particles of  $\text{ThO}_2$  plus optimal tungsten grain size, the granularity of tungsten powders, their manufacturing technology, welding temperature of piles and the influence of all these factors on the delamination tendency of the alloy were studied. The study involved ammonium paratungstenate, heated at 800-850°C until full decomposition (to  $\text{WO}_3$ ) occurred. A suspension was made of the tungsten trioxide, and a solution of thorium nitrate was added. The suspension was then evaporated and dried at 200-250°C, and the charge produced was reduced in an electric tube furnace in a medium of hydrogen at 800-880°C, producing a coarse-grained powder at 570-660°C followed by reduction at 730-870°C to produce a fine-grained powder. It is determined that the main reasons for delamination in wire and large accumulations of  $\text{ThO}_2$  particles, low density of welded piles, and large grain, caused by recrystallization annealing. Figures 4; references 5: all Russian.

USSR

UDC 621.763:669.15

FEATURES OF THE PRODUCTION OF POROUS PERMEABLE MATERIALS WITH ORGANIZED  
STRUCTURE MADE OF CONTINUOUS METAL FIBERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 9 (177), Sep 77 pp 38-43  
manuscript received 24 Dec 76

KARPINOS, D. M., RUTKOVSKIY, A. YE., ZORIN, V. A. and IVANCHUK, A. A.,  
Institute of Problems of Material Sciences, Academy of Sciences Ukr SSR

[Abstract] An interesting trend in the development of fiber metallurgy is the production of porous materials in which the initial elements are continuous fibers combined into screen intermediate products. These continuous screens, which have 3-dimensionality, elasticity and other valuable properties, can be used to create strong, anisotropic materials. This article investigates methods of production and study of the properties

of this type of material based on Kh18N9T stainless steel. Three technological plans for manufacture of porous specimens based on screens were tested: overpressing of materials with low assigned final porosity (10-40%), followed by expansion after strain relief and sintering; overpressing of specimens with high (over 50%) assigned final porosity, followed by sintering under pressure; and a method similar to the 2d method, plus preliminary sintering without the application of pressure, followed by pressing and final sintering. The pressed materials, due to their loop structure, consist of a springy fiber framework with significant elastic aftereffect. The third method of processing described above is preferable for the production of materials of low porosity and preassigned thickness. Sintering under pressure is preferable for the production of highly porous materials of assigned thickness. The strength characteristics increase as the sintering temperature approaches the melting point of the material of the fiber. The optimal sintering time is 2.5-3.5 hours. Some loss of material from the surface is observed when vacuum sintering is used. Figures 6; references 10: all Russian.

USSR

UDC 621.315.592

## SEMICONDUCTOR PERIODIC STRUCTURES---A NEW CLASS OF SEMICONDUCTOR MATERIALS

Moscow IZVESTIYA AKADEMII NAUK SSSR, NEORGANICHESKIYE MATERIALY in Russian  
Vol 13, No 7, Jul 77 pp 1133-1142 manuscript received 29 Jan 75

MASLOV. V. N., State Scientific Research and Planning Institute for the  
Rare Metals Industry

[Abstract] As semiconductor devices increase in complexity, both in chemical composition and in structural architecture, new properties arise. One very important property is the fact that periodic semiconductor structures, consisting, for example, of a large number (dozens or hundreds) of alternating p-n junctions or layers with various forbidden zone widths, have essentially new specific properties, which cannot be sufficiently described by the fundamental characteristic parameters used to describe ordinary homogeneous semiconductor materials: width of forbidden zone, concentration of charge carriers, mobility of charge carriers and lifetime of secondary charge carriers. A complete description of periodic structures requires the following additional characteristics: geometric periodicity characteristic (in 1 to 3 dimensions), symmetry and orientation of periodic structure relative to external actions; amplitude of change of periodically changing parameter; length of period and layers which make up a period (2 or more); and total number of periods. Studies on the growth of semiconductor periodic structures from the gas phase have been conducted in the author's laboratory since 1972. The method of epitaxial growth developed allows the growth of periodic structures consisting of two to several hundred layers with predetermined composition and level of doping and any desired thickness from 100 Å to several  $\mu\text{m}$ . Automated precision control of the rate of evaporation, in combination with a rather low precipitation temperature ( $580^\circ\text{C}$ ) has allowed the production of a superlattice with a period of 70 Å, consisting of 40-100 periods, each of which contains a layer of gallium arsenide 60 Å thick and a layer of  $\text{Ga}_{0.5}\text{Al}_{0.5}\text{As}$  10 Å thick. The structure was doped to a level of  $5 \cdot 10^{17} \text{cm}^{-3}$ . Areas 6  $\mu\text{m}$  in diameter were separated by photolithography, aluminum contacts were applied and the volt-ampere characteristics measured. At 2 v, an area of negative resistance was detected, one of the first effects theoretically predicted for the superlattice. The superlattice is but one case of a large variety of semiconductor periodic structures which can be produced by epitaxial growth. References 27: 16 Russian, 11 Western.

USSR

UDC 669.849:538.632

## HALL EFFECT IN SINGLE CRYSTALS OF RHENIUM AT LOW TEMPERATURES AND UNDER HYDROSTATIC PRESSURE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 5,  
May 77 pp 1088-1089 manuscript received after correction 25 Oct 76

KONDORSKIY, YE. I., GALKINA, O. S., CHEREMUSHKINA, A. V., TRUBITSIN, V. A.,  
and SHUTOV, I. A., Moscow State University imeni M. V. Lomonosov

[Abstract] A study is made of the Hall effect in single crystals of rhenium at 4.2°K and with pressure not exceeding 12 kbars. Hall e.m.f. was measured in two specimens measuring 3.2 x 0.92 x 0.4 mm with a ratio of resistivity at 295°K and 4.2°K equal to 250. In one specimen the normal line to the plane along which the magnetic field was directed was parallel to hexagonal axis  $c$  of the crystal, and in the other to axis  $[10\bar{1}0]$ . Electric current was passed along the long side of the specimen, in the first case along  $[10\bar{1}0]$ , and in the second parallel to axis  $c$ . The magnetic field was created with a superconducting solenoid rated at 50 kOe maximum. Both specimens were placed in the same vessel simultaneously for creation of hydrostatic pressure, which was measured potentiometrically. A previous study had demonstrated that a pressure less than or equal to 1.3 kbar on the Fermi surface of rhenium shifts the Fermi level. Another study of the Hall effect had shown that there is a reduction in the Hall constant in magnetic fields greater than 25 kOe when the field is directed parallel to the hexagonal axis and the current is passed along  $[10\bar{1}0]$ . This had been associated with the existence of magnetic breakdown. Another previous study had shown that in strong magnetic fields the Fermi surface of rhenium permits the presence of open orbits, which are open along axes  $[0001]$  and  $[10\bar{1}0]$ , and that in the second case open orbits originate as the result of magnetic breakdown. The data presented in this paper indicate that with an increase in pressure the gap between the electron and hole sheets of the Fermi level in rhenium increases, as a result of which the probability of magnetic breakdown is reduced. Pressure causes the greatest change in the Hall constant computed in low-strength magnetic fields when the magnetic field is directed parallel to axis  $c$ , and the current running through the specimen is parallel to axis  $[10\bar{1}0]$ . The Hall constant computed in high-strength magnetic fields, however, is virtually independent of the magnitude of pressure. When the magnetic field is directed along  $[10\bar{1}0]$  and the current runs parallel to  $c$ , the Hall constant for strong magnetic fields is reduced slightly under hydrostatic stress, which is possibly associated with a shift in the Fermi level under pressure. Figures 2; references 5: 2 Russian, 3 Western.

USSR

UDC 620.169.1:621.039.5

ON THE DEPENDENCE OF RADIATION DECREASE IN DURABILITY OF HEAT RESISTANT STEEL ON NEUTRON BOMBARDMENT PARAMETERS

Kiev PROBLEMY PROCHNOSTI in Russian No 9 (99), Sep 77 pp 42-45 manuscript received 20 Oct 76

KISELEVSKIY, V. N., and KOSOV, B. D., Institute of Strength Problems, Academy of Sciences Ukr SSR

[Abstract] A study is made of the possibility of approximate description of the durability of OKhl6N15M3B steel following neutron bombardment, using only the intensity of the flux of thermal neutrons as an argument in the equations. One prerequisite for this simplified description is the fact that statistical processing of the experimental data in the coordinates  $(R_T - 1) - \phi_{t_T}$ , where  $\phi_{t_T}$  is the thermal neutron radiation dose at the moment of fracture, has shown satisfactory accuracy for estimation calculations. The results of experiments performed confirm the correctness of estimating the durability of the bombarded steel by introducing the radiation parameter  $\xi = k\phi_T + (1 - k)\phi_B$ , where  $k$  is a weight coefficient. Also, correlation is found between the parameters of durability of this steel and the dose of thermal neutrons by the moment of failure as well as its intensity. No such correlation has been found with fast neutrons. Figures 5; references 3: all Russian.

USSR

UDC 669.141.4:621.311.2

AN INVESTIGATION OF THE KINETICS OF MECHANICAL PROPERTY CHANGES IN St3 STEEL AFTER HIGH TEMPERATURE TEMPERING

Moscow STAL' in Russian No 4, 1977 pp 362-363

BALAKHOVSKAYA, M. B., NADTSYNA, L. V., PERESKOKOVA, L. G. and OPARIN, A. A., Ural Branch of the All-Union Institute of Heat Technology

[Abstract] The possibilities for expanding the upper temperature range for utilization of boiled steel for pipes at thermal electric power stations were investigated for pipes of 730 x 7.5 mm made of open hearth steel of varying composition. The metal was tempered at 400°C with deformation, and also after preliminary deformation of 5 and 10%. Diffusion processes were hastened by the 400°C temperature, which was maintained for 100, 1000, 3500, and 10,000 hours. Test samples were cut in cross sections and tested at standard temperatures of 20, 300, and 400°C. In addition, impact strength was tested at - 20 and - 40°C. Results indicated that in

plastic properties, boiled steel was the equal of dead melt steels and in some properties surpassed them. The same held true for impact strength in the tested temperature range of 20 -- 400°C. At minus temperatures with "small perlite" boiled steel containing more structurally free cementite, the impact strength decreased in the - 20 and 40°C range. St3 boiled high carbon steel, despite its structural irregularities, had sufficiently high durability, impact strength and plastic properties for use as tubing. Figures 1.

USSR

UDC 669.14.0 3.29

#### RESISTANCE TO BRITTLE COLLAPSE OF St3sp and 18Gps STEELS

Moscow STAL' in Russian No 4, 1977 pp 359-361

GEORGIYEV, M. N., DANILOV, V. N., and MEZHOVA, N. YA., All-Union Scientific Research Institute for Railroad Transportation

[Abstract] The basic shortcomings of semi-dead melt steel in comparison to dead melt steels are their tendency to brittle collapse because of high gas content, high liquation of elements in the upper part of the ingot, and lack of uniformity. These weaknesses can be eliminated with proper processing, but without it semi-dead melt steels are no better than steels made by a boiling process. The comparison of St3sp and 18Gps steels in a hot-rolled state was done at the KommunarSKIY metal plant. In the St3sp steel melts the residual aluminum level was at or below the lower permissible limit. The 18Gps had 2 -- 3 times as much oxygen content as is found in dead melt steel. Dead melt and semi-dead melt steels were studied on the basis of their sulfur prints, and they were found to be essentially similar in sulfur distribution. The steels were also tested for brittle collapse under blows, and assigned to either the fifth or fourth categories according to the GOST standard 380-71. Results indicated that the steels tested had similar mechanical properties in many parameters, with some variations due to temperature reactions. The impact strengths of 18Gps at temperatures to - 40°C were higher, as were their energy absorption. After tempering, in the range - 20 to + 20°C 18Gps5 showed the greatest resistance to brittle collapse. Figures 4.

## USE OF HYPEREUTECTOID STEEL FOR CAST HOT ROLLING ROLLERS

Moscow STAL' in Russian No 4, 1977 pp 344-346

VORONTSOV, N. M., SKOBLO, T. S., RUDYUK, S. I., KUDRYAVTSEVA, L. G., and AVDEYEVA, L. M., Ukrainian Scientific Research Institute for Metallurgy; Metallurgical Plant imeni A. K. Serov

[Abstract] Tests have shown that rollers of relatively high carbon steel can successfully replace those of nickel-chromium cast iron. To preserve their hardness, such rollers were subjected to low temperature annealing at 650°C; they tested at 10-20 Brinell units less hard than the cast iron rollers, but they were equally hard at the caliber and on the perimeter, making possible a reduction of metal removal during sharpening and longer use between sharpenings. Production tests showed their durability to be 30% greater than for rollers of nickel chromium cast iron. Low temperature annealing did not change the steel's microstructure. The hypereutectoid steel rollers also permitted improvements in the rolled steel product. Use of thermal processing involving several stages, aimed at breaking down the coarse bonding network of the steel, spheroidization of perlite content, and increasing durability and flexibility, permitted use of these rollers on presses as well. Exact effects are reported for rollers of various diameters up to 600 mm. Application of several processing stages, including various combinations of annealing, normalization and tempering, significantly improved the durability of the cast steel rollers and offered important economic advantages over the traditional forced steel rollers: Figures 4; references 3: all Russian.

USSR

UDC 669.017:538

## ON MECHANISMS OF PULSED MAGNETIC REVERSAL OF THIN MAGNETIC FILMS IN WEAK FIELDS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 5,  
May 77 pp 998-1002 manuscript received 10 Aug 76

KOLOTOV, O. S., LOBACHEV, M. I., MUSAYEV, T. SH., POGOZHEV, V. A., and  
TELESNIN, R. V., Moscow State University imeni M. V. Lomonosov and  
Saratov State University imeni N. G. Chernyshevskiy

[Abstract] An experimental study was made of the structure of dynamic domains with reference to the form of the magnetic reversal curve for films of 79NMA permalloy. The magnetic reversal curve represents the relationship between the inverse time of magnetic reversal and the strength of the magnetic reversal field. Three separate sections of this curve are observed in magnetic reversal of films in weak fields. The nature of processes corresponding to the first two sections was dealt with in previous studies. This paper is concerned with studying dynamic domains which arise in the range of fields corresponding to the third section of the magnetic reversal curve directly adjacent to the nonuniform rotation section. Two stroboscopic magneto-optical units were used to study uniaxial polycrystal films obtained by thermal deposition. The light from one unit fell parallel to the axis of easy magnetization, and from the other perpendicular to this axis, thus making it possible to record the variation in magnetization in the direction perpendicular to the magnetic reversal field and to observe band domains. It is demonstrated that band domains form, followed by the origin and growth of breaks in the walls of these domains, both in the region of varied nonuniform rotation and in the range of fields studied here. This mechanism results in the appearance of a great number of domains at the edges and in the central regions of the film. Transition to the third section of the curve is observed with a magnetic reversal field strength close to the threshold field for varied nonuniform rotation. The mechanism of pulsed magnetic reversal within the range of fields corresponding to the third section of the magnetic reversal curve represents a transitional mechanism between the mechanism of growth of edge domains and that of varied nonuniform rotation. In addition to the growth of edge domains, within this range of fields a great number of narrow domains extended along the axis of easy magnetization appear, which are formed as the result of bursting of band domains. This mechanism is observed even in films thicker than 1000 Å. Figures 3; references 14: 6 Russian, 8 Western.



USSR

UDC 620.172.251.2

CREEP OF VT5-1 ALLOY WITH PROTECTIVE ENAMEL COATING IN AIR

Kiev PROBLEMY PROCHNOSTI in Russian No 9 (99), Sep 77 pp 46-48 manuscript received 26 Apr 77

UMANSKIY, E. S., TOVT, V. M., LYASHENKO, B. A., SITNIKOVA, A. YA., and TSYGULEV, O. V., Institute of Strength Problems, Academy of Sciences Ukr SSR

[Abstract] A study is presented of high-temperature creep of a titanium alloy with various enamel coatings in air under constant and cyclically changing temperature influences. The initial material is VT5-1 alloy, rolled into sheets 2 mm thick and covered with vitreous ceramic coatings 0.5-0.6 mm thick, then annealed for approximately 20 minutes. The coatings consisted of low-alkali compositions No 52 and 58 and high boron composition No 77. Annealing was at 850-1,000°C, depending on the composition of the coating. Creep testing was performed for up to 10 hours in a radiant heating device. It was found that coatings of No 58 enamel had a strengthening effect, while those of No 77 enamel had a plasticizing effect. Figures 3; references 4: all Russian.

USSR

UDC 669.295.017:620.178.74

ANISOTROPY OF CHARACTERISTICS OF FRACTURE OF SHEETS OF THE OT4-1u AND VT14 ALLOYS WITH VARYING CONTENT OF HYDROGEN AS A FUNCTION OF LOADING CONDITIONS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 3, May/Jun 77 pp 37-42 manuscript received 24 May 76

DROZDOVSKIY, B. A., PROKHODTSEVA, L. V., NOVOSIL'TSEVA, N. I., and PETROV, L. M., All-Union Scientific Research Institute for Aviation Materials, Moscow

[Abstract] A study was made of anisotropy on the basis of the fracture characteristics of sheets of the OT4-1u pseudoalpha titanium alloy with varying contents of hydrogen. Specimens with an initial crack were tested under static and impact loading as well as long-term tension. Furthermore, the anisotropy of VT14 alloy was studied in the annealed and thermally hardened states with varying contents of hydrogen. The tests included static bending with various reserves of elastic energy in the loaded system. The values of specific work of fracture were determined for impact and static bending; the time to fracture was determined for a given

stress and the nature of the logarithmic variation of stress intensity factor with crack growth rate was determined with long-term tensile loading. The specific work of crack development as the load decreases after the maximum under static loading was defined. References 9: 8 Russian, 1 Western.

USSR

UDC 620.194

RATE OF CRACK DEVELOPMENT AND ELECTROCHEMICAL CHARACTERISTICS OF AT-3  
TITANIUM ALLOY IN SEVERAL MEDIA

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 3,  
May/Jun 77 pp 110-112 manuscript received 18 Dec 74

FEDCHENKO, V. S., KRUTSAN, A. M., MELEKHOV, R. K., and BLASHCHUK, V. YE.,  
Institute of Physico-Mechanics, Academy of Sciences Ukr SSR; Institute of  
Electric Welding imeni Ye. O. Paton, Academy of Sciences USSR

[Abstract] A study is made of the influence of gaseous hydrogen on the kinetics of fatigue crack growth in AT-3 alloy, intended for use in the acid media of hydrolysis apparatus. Comparative experiments were also performed in air and in 0.6% solution of sulfuric acid. The studies were performed with flat specimens at 25°C under cyclic loading. Potentiostatic curves were also measured in 0.6% sulfuric acid at 20, 50 and 96°C and also in solutions of sulfuric acid with various additives. The annealed alloy was found to be most sensitive to crack growth. Hardening, partially imitating the structure of a welded seam without additional heat treatment, reduced the resistance of the metal to crack growth. The sulfuric solution greatly increased the rate of fatigue crack growth, but the effect of gaseous hydrogen was still greater. As the temperature was increased to 96°C, the area of passivity for 0.6% sulfuric acid was extended from -900 mv to -4,000 mv; addition of the additives did not change the cathodic branch of the polarization curve, except for glucose. Addition of formic or propionic acid increased the corrosive action of the solution for the alloy. However, the glucose, furfural and propionic acid, present simultaneously, narrowed the area of active dissolution of the alloy. References 8: 5 Russian, 3 Western.

USSR

UDC 669.295.018:539.4.01

INFLUENCE OF PHASE COMPOSITION ON FRACTURE TOUGHNESS OF VTZ-1 TITANIUM ALLOY

Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 6, Jun 77  
pp 1276-1280 manuscript received 9 Oct 76

TOMSINSKIY, V. S., IVANOV, A. S., KEYKOVA, N. V., and MAKHNEV, YE. S.,  
Perm' Polytechnical Institute

[Abstract] A study is made of the influence of phase composition on the nature of fracture and the parameters of structural strength of VTZ-1 alloy. It is shown that after hardening from the critical temperature, processes of aging leading to increased strength and brittleness of the alloy are activated at lower heating temperatures. The studies were performed by static bending testing of specimens 10x10 mm in cross section with a fatigue crack in order to determine the stress intensity factor. X-ray structural analysis and electron microscope studies were also performed. Fracture toughness can be increased in low temperature aging by relaxation of internal stresses which arise in hardening. Figures 2; references 6: all Russian.

USSR

UDC 669.295:669.017.3

STUDY OF VOLUMETRIC AND PHASE CHANGES UPON CONTINUOUS HEATING OF HARDENED VT16 ALLOY

Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 6, Jun 77  
pp 1259-1264 manuscript received 28 Sep 76

MAL'TSEV, M. V., KASHNIKOV, N. I., Gor'kiy Polytechnical Institute

[Abstract] Methods of dilatometry, x-ray structural analysis and measurement of mechanical properties are used to study the volumetric and phase changes occurring upon continuous (3°C/min) heating of VT16 alloy hardened from 780 and 790°C. With low temperature heating (up to 375°C) of the alloy, the maximum effect of decreasing the volume is observed if, as a result of hardening, two metastable phases  $\alpha''$  and  $\beta$  are formed in the alloy with primary content of the former. The decrease in volume results from transformation of the  $\alpha''$  phase to  $\beta$  phase and subsequent enrichment of the  $\beta$  phase with the alloying elements due to the separation of zones poor in alloying elements. The enrichment of the  $\beta$  phase which occurs with heating to over 375°C as a result of intensive diffusion redistribution of the alloying elements, conversely, is accompanied by an increase in volume of

the alloy. High temperature (over 400°C) decomposition of the  $\beta$  phase, forming  $\alpha$  and  $\beta$  phases of equilibrium composition, occurs with intermediate transformation of the  $\beta$  phase particles in the  $\alpha''$  phase, poor in alloying elements, in a very narrow temperature range. References 9: 8 Russian, 1 Western.

USSR

UDC 669.295.018:621.746.75

#### REGULARITIES OF LIQUATION PROCESSES IN TITANIUM ALLOYS

Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 6, Jun 77  
pp 1222-1227 manuscript received 12 Aug 75

TETYUKHIN, V. V., DENISOV, YU. P., KURAPOV, V. N., DUBROVINA, N. T.,  
Verkhnesaldinskiy Metallurgical Plant imeni V. I. Lenin

[Abstract] A study is made of the interrelationship between liquation in microvolumes and macrovolumes upon solidification of large masses of melted material. Ingots of titanium alloys produced in vacuum arc furnaces have an unusually rich selection of various forms of solid phase growth, beginning with a recticular surface and ending with "suspended" dendrites, making them valuable material for studies of this type. It is established that microheterogeneity increases with the transition from the recticular surface to the dendritic surface, and the appearance of zonal liquation in macrovolumes is determined by the solid phase growth form. As dendritic forms appear, the probability of appearance of local zonal or nonaxial V-shaped liquation increases from the side surface to the axis of the ingot. References 5: all Russian.

USSR

UDC 620.18

#### STRUCTURE-DEPENDENT EFFECTS OF ETCHING IN CERTAIN TITANIUM ALLOYS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul/Aug 77  
pp 99-107 manuscript received 21 Feb 77

AGEYEV, I. V., RUBINA, YE. B., BABAREKO, A. A., and KHOREV, A. I., Moscow

[Abstract] The interaction between hydrogen and certain titanium alloys (grades VT-23, VT-15, Ti-3Al-15Mo, and Ti-3Al-6Mo-6Cr) during chemical and electrolytic etching, with or without oxidation, is evaluated on the basis of a semiquantitative phase analysis by the x-ray diffraction method.

Chemical etching was done with an  $\text{HF}+\text{HNO}_3$  (1:1) mixture either concentrated or diluted in a water-glycerin solvent, and electrolytic etching was done with an  $\text{HF}+\text{H}_2\text{SO}_4$  (2.2:9) mixture diluted in water. Alloys VT-15 (Ti-2.5Al-7.5Mo-10Cr) and Ti-3Al-6Mo-6Cr were found to be unaffected by etching after any of the various heat- and thermomechanical treatments. Alloys VT-23 (Ti-5.3Al-2Mo-1Cr-4.5V-0.6Fe) and Ti-3Al-15Mo were found to be very sensitive to etching, with various phase transformations occurring in the surface layer depending on the heat- and thermomechanical treatment as well as on the etching mode. Other alloys were found to be selectively sensitive. The results indicate that packing defects and partial dislocations saturated with hydrogen during etching foster formation and precipitation of new phases. Etches ( $\alpha' + \alpha''$ ) titanium alloys produces a bcc phase, while etching ( $\alpha + \beta$ ) titanium alloys produces an fct hydride phase in Ti-3Al-15Mo or an hcc hydride in grade VT-23. Figures 3; references 13: 6 Russian, 7 Western.

USSR

UDC 669.295'292:542.6

#### AN INVESTIGATION OF MUTUAL DIFFUSION IN A TITANIUM-VANADIUM ALLOY

Moscow IZVESTIYA VUZ CHERNAYA METALLURGIYA in Russian No 3, 1977 pp 5-6  
manuscript received 20 Sep 76.

BALAKIR, E. A., ZOTOV, YU. P., MALYSHEVA, YE. B., PANCHISHNYY, V. I., and VOYEVODIN, V. P.

[Abstract] The initial material for the tests was titanium iodide after arc smelting, and vanadium of at least 99.99% purity. From these materials tablets 20 mm in diameter and 5 mm thick were cut, polished and fused by a diffusion welding process, at 700°C, for two hours at a specific pressure of 8 -- 10 kg/mm<sup>2</sup>. Micro-X-ray spectral analysis revealed no diffusion after welding. Diffusion annealing was conducted in a vacuum at no more than  $1 \cdot 10^{-4}$  mm Hg of residual gas pressure at temperatures of 900, 1100, and 1300°C for periods of 50, 25, and 3 hours, respectively. The breadth of the diffusion zones formed was not less than 200 mkm. The distribution of elements in the diffusion zone was determined by X-ray spectral analysis, with allowable error of less than 5%. The concentrational dependency of activation energy of mutual diffusion and the pre-exponential factor indicate that alloying titanium with vanadium is accompanied by significant changes in diffusion parameters and increased vanadium content in the solid solution, from 20 to 80%. Figures 3; references 2: both Russian.

USSR

UDC 621.791.753.9

ARC SPOT WELDING OF ALUMINUM-MAGNESIUM ALLOYS WITH INFUSIBLE ELECTRODES  
IN HELIUM

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 77 pp 69-71

TIMOSHENKO, A. N., LOZOVSKIY, V. P., and NOVIKOV, V. I.

[Abstract] During spot welding of aluminum-magnesium alloys, the required diameter of the core of the spot can be achieved by using an arc of high power, resulting in a large melted zone; as it crystallizes, a crater and crack are formed due to the great shrinkage of aluminum and its alloys. These defects can be eliminated by decreasing the size of the melted zone by concentrating the source of heat. With this purpose in mind, the combined influence of a short arc, activating paste and protective gas with high heat conductivity on the formation of a joint during arc spot welding was studied. The optimal thermal cycle of welding was selected, providing for the production of a joint with a narrow melted zone and the necessary spot core diameter. The cycle consists of heating, melting and welding of the crater. During the heating stage, the current is increased at 200-500 A/s to eliminate thermal shock. Subsequent melting is performed with a short arc at constant current. The crater is welded at reduced current with simultaneous stretching of the arc. The paste causes the arc to be displaced from the center of the spot to the outside portions, creating favorable conditions for crystallization of the spot weld. Figures 3; references 3: 2 Russian, 1 Western.

USSR

UDC 621.791.01:669.017.3

INFLUENCE OF AGING CONDITIONS OF WELDS OF VT14 ALLOY ON THE PHASE  
COMPOSITION AND PROPERTIES OF THE BASE METAL

Kiev AVTOMATICHESKAYA SVARKA in Russian No 6, 1977 pp 15-17 manuscript  
received after correction 22 Dec 76

CHERNETSOV, V. I., Candidate of Technical Sciences, and TSEYGER, YE. N.,  
engineer; Northwest Polytechnical Correspondence Institute, and KUSHNIRENKO,  
N. A., and ZAMKOV, V. N., Candidates of Technical Sciences, and TOPOL'SKIY,  
V. F., engineer, Ukrainian SSR Academy of Sciences, Institute of Electric  
Welding imeni Ye. O. Paton

[Abstract] Low-temperature aging (below 400°C) is used to increase the  
ductility and impact strength of the joint and base metal for welds of

VT14 alloy. This paper is devoted to studying the influence of heat treatment conditions on the phase composition of welds of titanium alloys, in order to discover the reasons behind this increase in ductility. Studies were made of a commercial VT14 alloy consisting of 3.85 percent Al, 1.14 percent V, and 3.21 percent Mo, the remainder being titanium. Phase composition was determined by x-ray structural analysis of thin sections in the initial state before heat treatment, after hardening from different temperatures within the 820 to 970°C range, and after hardening with high-temperature (480°C, 8 hours) and low-temperature (370°C, 8 hours) aging. VT14 alloy is characterized by alpha and beta phases in the initial state. Hardening from the temperature range studied fixes a metastable alpha-prime phase, representing a solid solution supersaturated with molybdenum and vanadium. Specimens hardened from 910°C and below show an alpha-double-prime phase in addition to the alpha-prime; there is more of this phase after high-temperature aging than after low-temperature aging. Use was made of the method of selective anodic phase isolation followed by x-ray structural and chemical analysis of anodic deposits to separate the beta and alpha-double-prime phases. Results are presented in tabular form. Data of a chemical analysis of the alpha-double-prime phase show that it is present in an amount of 2.5 to 4.0 percent in a hardened specimen and that it is richer in beta stabilizers than the alpha-prime phase (in molybdenum to a great extent). Aging of VT14 alloy is conducive to diffuse redistribution of alloying components in the alpha-prime and alpha-double-prime phases, owing to which these metastable solid solutions dissociate as follows:  $\alpha' \rightarrow \alpha + \alpha''$  (concentrated). As a result of this dissociation, increased alloying of the newly formed alpha-double-prime phase takes place and its quantity in the alloy increases, depending on aging conditions. It is present in a quantity not exceeding six percent with low-temperature aging, whereas high-temperature aging results in 10 percent. The alpha-double-prime phase has a rhombic lattice, like that of the alpha phase. The more the alpha-double-prime phase is alloys, the more depleted of beta stabilizers the alloy's base--the alpha phase--becomes in the aged state. Aging results in a less drastic difference between the alpha and alpha-double-prime phase with respect to chemical composition and strength, which explains the favorable combination of strength and ductility in VT14 alloy. References 4: all Russian.

USSR

UDC 621.791.75.042

# ELECTRODES FOR WELDING OF EI943 AND EP516 STABLE AUSTENITIC ALLOYS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 77 pp 68-69

KAKHOVSKIY, N. I., LIPODAYEV, V. N., and UKOLOVA, YE. N.

[Abstract] In order to develop improved electrodes, the Institute of Electric Welding has performed investigations using a method developed at the Moscow Higher Technical School into the influence of molybdenum, manganese, vanadium, cobalt, tantalum and niobium on the technological strength of seam metal produced during manual arc welding. Molybdenum and manganese (the latter at up to 2.5%) were found to have a positive influence; niobium, cobalt, vanadium and tantalum had a negative influence. Characteristically, the negative influence of vanadium is much weaker than that of niobium. Metallographic and microscopic x-ray analysis of the seam metal have shown that the negative influence of these elements results from the appearance in the interdendritic layers of a second, apparently low-melting, phase. Considering experimental data and experience, new type ANV-28 electrodes were developed for welding of EI943 and EP516 steels. The electrodes provide the required resistance of the metal of the multilayer seam to intercrystalline corrosion and result in the following chemical composition of the melted metal (%): C 0.04, Si 0.3, Mn 2.4, Cr 22.5, Ni 26.5, Cu 3, Mo 4.5, V 1.1, S 0.01 and P 0.015. The seam metal has a tensile strength of 63 kg/mm<sup>2</sup> and a yield point of 44 kg/mm<sup>2</sup>. Figures 3; references 3: all Russian.

USSR

UDC 621.791.052:620.18

# METHODOLOGY OF PREPARING MICROSECTIONS OF WELDS OF HIGH-STRENGTH TITANIUM ALLOYS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 6, 1977 p 75

POTAPENKO, L. A., engineer, and SIDLYARENKO, V. A., technician

[Abstract] The current technology of preparing microsections and defining the structure of titanium welds is not suitable for high-strength titanium alloys. An hour is required for preparation of a single specimen and microscopic ripples form. A new technology has been developed at the Institute of Electric Welding. The surface is treated with emery cloth and the microsection is placed in an electrolyte made up of 160 cm<sup>3</sup> acetic acid, 200 cm<sup>3</sup> hydrofluoric acid, 160 cm<sup>3</sup> sulfuric acid, and 50 cm<sup>3</sup>



nitric acid. Electrolytic polishing is carried out with voltage between 25 and 35 V for 10 to 20 seconds, depending on the composition of the material. The electrolyte is stirred during polishing. After polishing the specimen is rinsed with tap water and dried. Then it is polished mechanically for 30 to 60 seconds. Specimens can then be etched chemically or electrolytically. Electrolytic etching yields the best results. Composition of the electrolyte is the same for etching as for polishing, but voltage is within 20 to 28 V and the process lasts 5 to 10 seconds. A relief is thereby obtained which corresponds to structural components. A photograph of an example is shown. The entire process takes 4 to 5 minutes, with good results.

USSR

UDC 621.791.01

CALCULATION-EXPERIMENTAL DETERMINATION OF THE PARAMETERS OF AUTOMATIC MICROPLASMA WELDING MODES FOR SPECIAL THIN-SHEET STRUCTURES

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 77 pp 35-37 manuscript received 30 Mar 77

VERBITSKIY, V. G., GIL'DIN, G. M., ARDASHIROV, N. SH., and SMIRNOV, A. YU., Ufa Aviation Institute imeni S. Ordzhonikidze

[Abstract] An attempt is made to use the method of assigning the limits of change of certain geometric dimensions of the welding bath to determine the optimal modes of microplasma welding on the basis of the permissible limits of geometric dimensions of the bath over a broad range of change of energy per unit seam length. The empirical formulas produced allow the geometry of the bath to be determined over a broad range of microplasma welding modes for thin sheet structures of type 12Kh18N10T steel, as well as the zone of maximum possible mode variations. Using the graphic method suggested, the parameters of welding modes for other thin sheet materials can be determined. Figures 4; references 5: all Russian.

## HYDROGEN IN THE METAL OF THE SEAM IN OPEN-HEARTH HIGH STRENGTH STAINLESS STEEL WITH ARGON-ARC WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 77 pp 15-19 manuscript received 27 Oct 76

VOZNESENSKAYA, N. M., POTAK, YA. M., (deceased), KUROCHKO, R. S., PASTUKH, M. N., and YADROV, V. M., All-Union Institute of Aviation Materials

[Abstract] This work presents a study of the sources of hydrogen and its influence on the properties of the seam metal during argon-arc welding of high-strength stainless steels. This work is undertaken in connection with the fact that cracks have appeared in production situations at the center of a seam, the metal of which was found to have an elevated hydrogen content. Seams of great thickness (20-30 mm) in type VNS-2 steel welded with addition of titanium and with the new type EP659A-VI welding wire were studied. The chemical composition of the steel is (%):  $C < 0.08$ , Cr 14, Ni 5.3,  $Si < 0.7$ ,  $Mn < 1.0$ , Ti 0.05, Cu 2. The composition of the new welding wire is (%):  $C < 0.03$ , Cr 11.8, Ni 8.7, Si 1.5, Mn 0.75,  $Ti < 0.05$ , Mo 2; the wire also contains rare-earth elements. It is found that the main source of diffusion-mobile hydrogen in the seam is the increased moisture content of the argon and the surrounding atmosphere which results from improper protection of the arc. Hydrogen does not enter the seam from the welding wire or base metal. Welded seams made with the new welding wire are less sensitive to hydrogen than seams made with the older type EP410USH wire. The content of a diffusion-mobile hydrogen is greatly reduced by tempering at 300°C, the time depending on the thickness of the material. Figures 2; references 4: all Russian.

USSR

UDC 621.318.12:536.42

THE PHASAL STRUCTURE OF ALLOYS OF THE TICONAL TYPE AFTER TEMPERING AT TEMPERATURES OF 800-850°C

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 3, 1977 pp 652-654 manuscript received 13 May 76

SUMIN, V. I., FRIDMAN, A. A., PASHKOV, P. P., RABINOVICH, YU. M., and AL'TMAN, V. A., All-Union Scientific Research Institute of Electromechanics, Moscow

[Abstract] Ticonal alloys with a biphasal structure under certain circumstances have an apparent triphasal structure at temperatures of 800-850°C. X-ray analysis was used in the present study to confirm this tri-phasal structure and determine its properties. X-rays of specimens that were air-cooled after annealing at these temperatures did not show such a third phase, thus indicating a transformation from a triphasal to a biphasal structure. The existence of the triphasal structure helps to explain the "reversal" of magnetic properties in ticonal alloys. Figures 3; references 5: 4 Russian, 1 English.

USSR

UDC 539.23-216.2

PRODUCING SUPERCONDUCTIVE FILMS OF NIOBIUM AND NIOBIUM-GERMANIUM ALLOYS BY THE ELECTRON-BEAM SPUTTERING PROCESS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul/Aug 77 pp 152-153 manuscript received 23 Apr 76

SAVITSKIY, YE. M., BARON, V. V., BYCHKOVA, M. I., and SUMAROKOV, V. N., Moscow

[Abstract] Superconductive films were produced by the electron-beam sputtering process, either from the Nb<sub>3</sub>Ge compound or from niobium and germanium fed separately. The first method did not yield films of stoichiometric and stable composition, because of the preferred evaporation of germanium and the corresponding variation of the melting point of the film. The second method yielded films 4000 Å thick. Films with 11.1 or 23.1 at.% Ge contained the bcc α-Nb phase in solid solution, films with 24.2 or 28.8 at.% Ge contained the Nb<sub>3</sub>Ge compound with an A-15 lattice and in some cases excess germination. The superconducting transition temperature of niobium-germanium alloys with a bcc lattice is lower (8.4°K) than that of pure niobium, indicating a typical solubility of germanium in niobium. The superconducting transition temperature of the compound is much higher, ranging from 10 to 17.9°K. The substrate temperature for niobium-germanium films must be 650°C, compared to 700°C for pure niobium films. Figures 2; references 4: 1 Russian, 3 Western.

USSR

UDC 539.4.014.2

EFFECT OF PRETWISTING ON THE HARDENING OF ACICULAR COPPER CRYSTALS UNDER UNIAXIAL TENSION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul/Aug 77  
pp 95-98 manuscript received 24 Dec 76

KOSILOV, A. T., BELIKOV, A. M., KAZANSKIY, V. M., and KOLTUNOV, Voronezh

[Abstract] Acicular copper crystals with [110] growth orientation are considered in this study. The effect of predeformation by twisting on their strain hardening under tension is analyzed, on the basis of experimental data, and interpreted in terms of the behavior of the dislocation structure during changes in the state of stress. Four stages of such a hardening process are distinguishable: (I) microplastic deformation; (II) monotonically decreasing strain hardening due to plastic flow and attendant increase in the dislocation density; (III) softening of the crystal due to avalanche spreading of dislocations; and (IV) weak hardening attributable to four equivalent group-IV slip systems alternately dominant during progressive deformation. Damping and internal friction also play a role in the process, the former increasing during stage (II) and the latter anomalously increasing during stage (III). Figures 3; references 7: all Russian.

USSR

UDC 669.24:548.4

BASIC STAGES IN THE FORMATION OF SECONDARY BOUNDARIES IN THE CRYSTALLIZATION OF THE LIQUID PHASE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 3, 1977 pp 622-628 manuscript received 13 Sep 76

MOVCHAN, B. A., BORISOVA, N. N., Institute of Electric Welding imeni Ye. O. Patou, Academy of Sciences Ukr SSR

[Abstract] Cast metals and alloys have secondary boundaries of crystallites that are in random distribution to the primary dendrite or basaltiform crystalline boundaries. The secondary boundaries may join the primary crystals into larger ones, or on the other hand further divide them. The observations reported indicate that during cooling these secondary boundaries gradually form as the substructure disappears. Bending brings a new crystallographic disorientation of the adjacent volumes. The formation of secondary boundaries occurs during a temperature interval below

the point of solidification as a result of a multi-stage polygonization process, which also involves the primary crystals. Investigations with an electron microscope confirm that the sphere boundaries have a dislocational structure with acute angles not exceeding 2 -- 4°. Decrease in the cooling rate of hardened specimens was accompanied by a disappearance of the remaining spherical substructure and the appearance of well-defined secondary boundaries on the microfacets. It follows that in metallic materials, just as in transparent  $\text{NaNO}_3$ , high temperatures and internal tensions cause a transformation of the substructure into a boundary with obtuse signals. This is a process of internal relaxation of tensions and perfection of the crystalline structure. Figures 7; references 21: 17 Russian, 2 German, 2 English.

USSR

UDC 669.04:536.4

#### THERMODYNAMICS OF $\text{TiO}_2$ SYNTHESIS BY COMBUSTION OF $\text{TiCl}_4$ IN OXYGEN

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 4, Jul/Aug 77  
pp 53-58 manuscript received 20 Sep 76

RYKALIN, N. N., KULAGIN, I. D., KULIKOV, I. S., ROZHDESTVENSKIY, I. B.,  
FEDOROV, V. B., KALININ, P. I., SOROKIN, L. M., ANTIPOV, I. V., and  
GUGNYAK, A. B., Moscow

[Abstract] The thermodynamics of the synthesis of titanium dioxide by combustion of titanium tetrachloride is analyzed on the basis of computer-aided calculations pertaining to the composition of vapor-gas and condensate phases, with all the possible compounds forming during such a synthesis taken into account. The gaseous phase is regarded as a mixture of ideal gases and the condensate is regarded as an ideal solution of liquid or solid components with infinite solubility. Various modes of synthesis are considered, differing only in the amounts of oxygen: six reactions with molecular oxygen ranging from 50 to 200% of its stoichiometric amount and one reaction with molecular and atomic oxygen in equal amounts. The results indicate that oxygen deficiency reduces the amount of condensate consisting of various titanium oxides. A stoichiometric relation produces a mixture of rutile and anatase, the concentration of the former decreasing from about 95% at 500°K to about 70% at 1500°K. Excess oxygen added at 1500°K produces about 3% more condensate with about 9% more rutile. The thermodynamic analysis indicates that the optimum temperature range for rutile ( $\text{TiO}_2$ ) synthesis is 1140-1582°K. Above that range the rate of its synthesis becomes too slow, while below that range other titanium oxides and eventually titanium chlorides will also enter into the condensate. Figures 3; references 7: 4 Russian, 3 Western.

USSR

UDC 669.:539:67

ON THE DAMPING CAPACITY OF Ni-SiO COMPOSITE COATING MATERIALS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 3, 1977  
pp 654-657 manuscript received 20 May 76

ZOLOTUKHIN, I. V., IL'INSKIY, A. I., KOMBAROV, V. V., BILETCHENKO, N. M.,  
and SAVCHENKO, I. A., Voronezh Polytechnical Institute and the Khar'kov  
Polytechnical Institute

[Abstract] The test materials were obtained by vacuum condensation of alternating layers of Ni and SiO. Internal friction was determined using specimens of 3 x 20 x 0.03 mm. High damping levels were apparently related to the disintegration of the SiO and the formation of a solid solution of silicon and oxygen in nickel. This is confirmed by the fact that after annealing at 900° the damping effect decreases greatly. Since the materials tested had fine textures, they can be regarded as similar in effects to the damping related to the boundaries between Ni and SiO granules. The materials tested can be utilized for muffling vibrations and oscillations within the range of human hearing. Figures 2; references 13: 10 Russian, 3 Western.

USSR

UDC 669.5'.715

OBSERVATION OF DISLOCATIONS IN SUPERPLASTIC DEFORMATION OF ALLOYS OF THE Zn-Al SYSTEM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 235, No 6, 1977 pp  
1293-1296 manuscript received 17 Mar 77

KAYBYSHEV, O. A., RODIONOV, B. V., and VALIYEV, R. Z., Ufa Aviation  
Institute imeni Ordzhonikidze

[Abstract] The purpose of this study was to develop a methodology for fixing and studying the dislocation structure of alloys of the Zn-Al system after superplastic flow. In the process of cooling specimens from the softening point considerable changes in the dislocation structure can take place as the result of flow of dislocations toward grain boundaries, a process which is activated especially because of the considerable length of regions near boundaries in superplastic materials. Earlier studies have explained the absence of a dislocation structure after deformation in regions I and II of the superplastic flow curve as resulting from the diffusive nature of superplastic flow. In the experiments described here the structure typical of superplastic deformation was preserved by freezing

specimens at the instant that deformation terminates. In the thermal chamber of an "Instron" unit a special apparatus was developed to make it possible to relieve the specimen before cooling to prevent cold hardening and to automatically supply water to achieve a specific degree of deformation. A special study showed that cooling does not result in formation of a dislocation structure. After cooling, specimens were stored in liquid nitrogen and all foil-preparation operations were performed at low temperatures. This made it possible to minimize the possibility of the dislocations disappearing in the process of preparing the specimens for study. Use of the quenching apparatus made it possible to fix dislocations even with rates of straining corresponding to region I of the superplastic flow curve, whereas after ordinary cooling dislocations are absent in both phases even after deformation of specimens with a considerably great rate of straining. A determination was made of dislocation slip planes and their Burgers vectors. The use of the quenching unit made it possible not only to study features of intergranular slip, but also to establish certain patterns in the behavior of grain boundaries. Freezing the specimens immediately upon termination of deformation made it possible not only to discover the presence of line defects in grain boundaries, but also to determine their nature. It was established that these defects are lattice dislocations located at grain boundaries. Under conditions of an exceptionally fine-grain structure effective slip systems in the beta phase under the same temperature-vs.-rate conditions depend on the phase composition of these alloys. The preferred slip system depends not only on the Schmidt factor, but also on the energy for formation of dislocations at the surface. It is probable that generation of nonbasal dislocations at boundaries between phases is more favored from an energy standpoint than that of basal. Formation of grain-boundary dislocations takes place when lattice dislocations interact with boundaries. The increase in grain boundary defects which results from this leads to an increase in their nonequilibrium and to hastening of grain boundary migration and grain-boundary slip, whose intense effect is observed in superplastic flow. It is recommended that the results obtained here be taken into account in analyzing the nature of the effect of superplasticity. Figures 3; references 7: 4 Russian, 3 Western.

USSR

UDC 669.017.539.4

#### ON THE ANOMALOUS SENSITIVITY OF METALS TO A NOTCH UNDER CONDITIONS OF SUPERPLASTICITY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 235, No 6, 1977 pp 1300-1302 manuscript received 27 May 77

BELOV, A. F., Academician, MIKLYAYEV, P. G., DUDENKOV, V. M., and KUDRYASHOV, V. G.

[Abstract] Metals have been divided into those sensitive and insensitive to stress concentration. In the first a notch reduces both the strength and

ductility of the metal, whereas in the second it increases strength and reduces ductility. This paper gives the results of a study of the influence of a notch on the sensitivity of metals to stress concentration under conditions of superplasticity. Data are presented from tensile testing cylindrical specimens with a notch in the superplastic state; the following alloys were used: VTZ-1, Al-78% Zn, Al-68% Mg, VKh4, and MA12. The presence of a notch is conducive to great ductility in a superplastic material. A notch as it were "weakens" a superplastic material, i.e., the ratio between the ultimate strength of a notched specimen and that of an unnotched specimen is considerably less than unity for the majority of the specimens studied. For MA12 magnesium alloy in the superplastic state a stress concentrator, increasing ductility, also increases its ultimate strength markedly. This proves that the influence of a stress concentrator on resistance to strain depends on the nature and structure of the material, for in the specific case studied here MA12 has a solid solution structure at superplasticity and a close-packed cluster lattice, whereas the structure of the other two alloys represented a mixture of two base phases. A study of the influence of the radius of the notch on strength properties of an alloy in the superplastic state demonstrated that the sharper the notch, or the higher the stress concentration and the greater the localization of strain, the lower the ratio between the ultimate strength with and without the notch. A sharp notch creates a three-dimensional stressed state during tensile testing and causes concentration of stress; this is conducive to formation of a great number of vacancies, resulting in hastening the start of superplastic flow owing to an increase in the rate of occurrence of diffusion processes which are responsible for superplastic deformation. The sharper the notch, the greater extent to which resistance to strain is reduced. The curve describing the contour of the location of the notch after testing obeys an exponential law, and the index of the exponential function, whose formula is given here, is intimately associated with the degree of superplasticity of the alloy. The more superplastic the alloy, the lower this index. The results obtained here prove that ductile properties of superplastic alloys are insensitive to stress concentrators, and that their strength properties (resistance to strain) are sensitive to stress concentrators in an "inverse" manner. Figures 2; references 3: all Russian.

USSR

UDC 539.67:669.15'74.017.1

ON THE NEW INTERNAL FRICTION MAXIMUM IN ORDERED ALLOY Fe 2.86%, Si 0.07%

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 5, May 77 pp 1095-1096 manuscript received after correction 25 Oct 76

PIGUZOV, YU. V., DRAPKIN, B. M., and IVANOV, YU. N., Rybinsk Aviation Technology Institute

[Abstract] A study is made of internal friction in alloy Fe 2.86%, Si 0.07%. Specimens were heated to 700° in an oxygen-free environment and slowly cooled.



They were held at 700° for one hour and five hours, respectively, and cooled to room temperature in running water. Disordered specimens, i.e., those cooled after soaking for five hours, were brought to the ordered state by being subjected to isothermal annealing for 10 hours at 300°. An increase in Young modulus and microhardness indicated formation of a superlattice under these conditions. Temperature vs. internal friction curves for specimens in the parent, cooled, and isothermally annealed states revealed, in addition to a well-defined peak caused by migration of carbon atoms in the alpha-Fe lattice, another internal friction maximum in the 300° region. This was true of all specimens except that cooled after five-hour soaking, which revealed only a slight bend. The new peak was thus associated with the presence of a superlattice. A study of activation energy for the process causing this maximum and the similarity of its behavior with that of the other peak made it possible to suggest that the new peak is associated with the presence of carbon atoms in lattice interstices. These hypotheses were tested by studying alloys with different carbon contents. It is concluded that this new maximum is observed only with the presence of added carbon atoms and a superlattice. The position of this peak when plotted against temperature and its activation energy depends on the degree of the long-range order. The height of this peak is controlled by the content of carbon in interstices of the crystal lattice. The conditions for appearance of this peak do not agree with those for other peaks observed. This is a new peak which can be explained by migration of carbon atoms in the ordered phase under the influence of variable stresses. The relationship between appearance of this peak and the presence of an ordered phase in a body-centered cubic lattice and the presence of added atoms gives this new maximum great significance. It is possible to use this maximum for detecting a superlattice and added impurities, as well as for calculating diffusion parameters. Figures 3.

USSR

UDC 621.165.539.432

#### EXPERIMENTAL STUDY OF STRENGTH WITH DROP-IMPACT LOADING

Kiev PROBLEMY PROCHNOSTI in Russian No 6, Jun 77 pp 110-113 manuscript received 26 Jan 76

ALEKSEYEV, V. K., BODRISHEV, V. V., DENISOV, YU. D., and PEREL'MAN, R. G., Moscow Aviation Institute

[Abstract] A study is made of the process of dynamic loading of materials upon high-velocity collision with a liquid metal gallium-indium-tin alloy in drops 1 and 2 mm in diameter and drops of water. The nature of deformation and damage to organic glass is studied and photographs and profilegraphs of the damaged surfaces are presented. Collisions were performed perpendicularly

to a flat surface of the material at velocities of 100-300 m/sec. The liquid alloy has a melting point of  $10.5^{\circ}\text{C}$  and a density of  $6\text{ g/cm}^3$ . The depth of plastic deformation was found to increase in proportion to collision velocity. The experiments indicated the peculiarities of deformation and fracture of a material in the zone of dynamic local contact with the curved surface of a liquid drop and also extend the characteristics of dynamic strength of polymethylmethacrylate into the area of loading times of  $10^{-7}$ - $10^{-9}$  sec. Figures 4; references 11: 8 Russian, 3 Western.

USSR

UDC 669.017:669.296'292

#### AREA OF EUTECTOID TRANSFORMATION IN THE Zr-V SYSTEM

Minsk IZVESTIYA AKADEMII NAUK BSSR. SERIYA FIZIKO-TEKHNICHESKIKH NAUK  
in Russian No 1, 1977 pp 35-36 manuscript received 16 Apr 76

SIROTA, N. N. and MALISHEVSKIY, V. F., Institute of Solid State Physics  
and Semiconductors, Academy of Sciences BSSR

[Abstract] This work has as its purpose the determination of the temperature and composition of the eutectoid point and the course of the line limiting the  $\beta$  phase near the eutectoid temperature in the Zr-V system. The studies were performed using alloys produced in an arc furnace with an infusible tungsten electrode in an atmosphere of purified argon on a copper, water-cooled bottom. The initial components used were iodide zirconium and aluminothermic vanadium, containing 0.01% Al, 0.02% Fe, 0.2% Si, 0.02% C, less than 0.01%  $\text{N}_2$  and less than 0.02%  $\text{O}_2$ . The results produced indicate that the eutectoid point is located between 4.0 and 4.2 wt.% vanadium. This result falls between results produced in earlier works, probably because of the increased purity of the initial components used in the present work. The temperature of the eutectoid transition was defined as  $777 \pm 2.5^{\circ}\text{C}$ . Figures 2; references 3: all Western.

USSR

UDC 669.245'26:539.22

FURTHER ORDERING OF THE MATRIX OF COMPLEXLY ALLOYED NICKEL-BASED HEAT-RESISTANT ALLOYS

Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 6, Jun 77  
pp 1265-1275 manuscript received 28 Sep 76

RTISHCHEV, V. V., VINTAYKIN, YE. Z., PIGROVA, G. D., and UDOVENKO, V. A.,  
Central Boiler and Turbine Research and Design Institute

[Abstract] A study is made of the change in the phase composition, structure and properties of experimental and industrial alloys based on nickel and chromium, alloyed with tungsten, molybdenum, titanium and aluminum, upon long-term aging in the 450-650°C temperature interval. It is found that the changes in physical and mechanical properties which are observed result from combined occurrence of processes of decomposition and short and long-range ordering of the matrix of  $Ni_2Cr$  type. The formation of the  $Ni_2Cr$  superstructure is possible, in spite of the relatively low content of chromium in the matrix due to the presence of tungsten and molybdenum, which replace the chromium atoms in the superstructure. Figures 6; references 25: 16 Russian, 9 Western.

USSR

UDC 539.89

STUDY OF PHASE TRANSFORMATIONS IN A SOLID IN A HIGH PRESSURE CHAMBER BY MEANS OF A PISTON MANOMETER

Moscow FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 6, Jun 77  
pp 1212-1221 manuscript received 25 Nov 75

VERESHCHAGIN, L. F. (deceased), ZUBOVA, YE. V., STUPNIKOV, V. A., Institute of High Pressure Physics, Academy of Sciences USSR; Moscow State University

[Abstract] A free-piston manometer is used to study phase transformations at pressures of up to 60 kbar. The nature of polymorphous transformations in bismuth, thallium and barium, widely used for calibration of high pressure apparatus, is determined in the temperature range from room temperature to 100°C. Both forward and reverse transformations were studied, using identical chambers, measurement apparatus and experimental conditions. The results produced indicate that the current state of confusion can be partially alleviated by selecting a polymorphous transformation point at a temperature such that the difference between the pressure of forward and reverse transformation is minimal or zero. Figures 5; references 32: 6 Russian, 26 Western.

USSR

UDC 669.24.25:548.5

AN INVESTIGATION OF METASTABLE STRUCTURES IN Ni-Be AND Co-Be SYSTEM PRODUCED BY ULTRAFAST COOLING FROM THE MOLTEN STATE

Ordzhonikidze TSVETNAYA METALLURGIYA in Russian No 4, 1977 pp 113-116  
submitted for publication 17 Feb 76

VARICH, N. I., SAVICH, V. I. and PETRUNINA, A. N., Dnepropetrovsk State University, Department of Metal Physics

[Abstract] Metastable Ni-Be and Co-Be alloys of eutectic composition were produced by cooling from the molten state at rates of  $10^5$ - $10^8$ °C/sec. The normal phase diagrams for the studied systems are quite similar but, when cooled at ultrafast rates, somewhat different metastable structures are produced. In the Ni-Be system, when cooled at the rate of  $10^7$ - $10^8$ °C/sec, the region of the Ni-base solid solution expands to 30 at.% Be as compared to the maximum solubility of Be (16 at.%) at the eutectic temperature under equilibrium conditions. A further increase in Be content (above 31 at.%) leads to the formation of a new metastable phase which exists in the interval of 31.5-35.5 at.% Be as a b.c.c. structure with lattice parameters of  $a = 3.647$  Å,  $b = 2.578$  Å and  $c = 3.914$  Å. A new metastable phase was also found in the Co-Be system when cooled at high rates. This phase existed in the concentration interval of 16-40 at.% Be with a tetragonal structure and lattice parameters of  $a = 2.658$  Å and  $b = 2.736$  Å. Changes of electronic states with temperatures was deemed to be the reason for the differences in the resultant metastable structures in the Ni-Be and Co-Be systems. Figures 2; references 6: 5 Russian, 1 Western.

USSR

UDC 546.26:539.261

INFLUENCE OF HIGH PRESSURE ON THE STRUCTURE OF CERTAIN CARBON MATERIALS

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian Vol 13, No 8, Aug 77 pp 1424-1428 manuscript received 24 Mar 76

SHTERENBERG, L. YE., BOGDANOVA, S. V., and SLESAREV, V. N., Institute of High Pressure Physics, Academy of Sciences USSR

[Abstract] This work presents a study of the influence of pressure at 37 kbar and above at 1500°C on the structure of certain carbon materials used for the synthesis of diamond. The initial materials used were natural graphite, artificial graphite, cokes made of polyvinyl chloride and polyvinylidene chloride, channel black and thermal black. All of the materials

except the graphite were preliminarily heat treated at 1 atm in argon at 2000°C. It was found that high quasi-hydrostatic pressure acting on three-dimensionally ordered carbon materials produces an increase in the defect rate of the structure of the materials, accompanied by a decrease in the spacing between layers. Graphitization of nongraphitizing carbon materials and disordering of graphite materials at high pressure showed that when carbon is classified, one should indicate the pressure at which the classification applied is valid. References 10: 7 Russian, 3 Western.

USSR

UDC 621.762.5

#### THE KINETICS OF SINTERING OF $\text{Eu}_2\text{O}_3$

Moscow IZVESTIYA AKADEMII NAUK SSSR, NEORGANICHESKIYE MATERIALY in Russian Vol 13, No 7, Jul 77 pp 1262-1265 manuscript received 29 Aug 73

KIPARISOV, S. S., ANDRYUSHIN, A. I., KUZNETSOV, S. A., KOZLOV, V. G., and BELYAKOV, A. I., Moscow Institute of Steels and Alloys

[Abstract] A report is presented on a study of the kinetics of compacting products of  $\text{Eu}_2\text{O}_3$  powders of various types subjected to various preliminary processing in air.  $\text{Eu}_2\text{O}_3$  powders were pressed into cylindrical products 10 mm in diameter and 5 mm high, which were sintered in air at 800-1500°C for one hour. It is shown that the method of production and preliminary processing of the  $\text{Eu}_2\text{O}_3$  has a significant influence on the relative linear shrinkage and density of the products after sintering. It is established that the kinetics of sintering of products of  $\text{Eu}_2\text{O}_3$  can be described by a parabolic equation. References 10: 6 Russian, 4 Western.

USSR

UDC 621.317.8:621.396

#### PRODUCTION AND PROPERTIES OF COMPLEX BORIDES IN THE SYSTEM $\text{CaB}_6\text{-SmB}_6$

Moscow IZVESTIYA AKADEMII NAUK SSSR, NEORGANICHESKIYE MATERIALY in Russian Vol 13, No 7, Jul 77 pp 1314-1315 manuscript received 17 Mar 76

SAMSONOV, G. V. (deceased), RUD', B. M., SHULISHOVA, O. I., KONOVALOVA, YE. S., MUDROLYUBOV, YU. M., and BUDANOVA, I. G., Institute of Problems of Material, Academy of Sciences Ukr SSR

[Abstract] Complex borides  $(\text{Ca}_x\text{Sm}_{1-x})\text{B}_6$  were produced by borothermic reduction of the corresponding mixture of metal oxides by two methods:

hot pressing of the initial powders and vacuum sintering of the powders. The composition and structure of the borides was tested by x-ray, chemical and metallographic analysis. The materials produced by the first method had high values of temperature coefficient of resistance, while their resistivity depended little on composition. The materials produced by vacuum sintering had relatively lower TCR, which changed more with composition, while the resistivity increased with increasing Ca content. The influence of hydrogen on the electrical properties of the boride was studied at liquid nitrogen temperatures, room temperature and temperatures up to 1000°C (12 hours). The maximum quantity of hydrogen was absorbed at liquid nitrogen temperature, 12 cm<sup>3</sup>/g. Resistivity before and after hydrogenation was the same within the limits of error of the experiment, indicating that the hydrogen was only adsorbed on the surface of the specimen, and did not interact with it. References 2: both Russian.

USSR

UDC 669.15.018.8-194.56:539.43

#### KINETIC OF GROWTH OF FATIGUE CRACKS IN STEELS AND TITANIUM AND NICKEL ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKhanika MATERIALOV in Russian Vol 13, No 3, May/Jun 77 pp 20-26 manuscript received 22 Jul 76

MASLOV, L. I., ARITA, M., and BEZHENOV, A. I., Institute of Metallurgy imeni A. A. Baykov; Tokyo Shipbuilding Institute

[Abstract] A study is made of the stages of development of cracks during fatigue loading of Type 35 steel and of nickel and titanium alloys. The mechanical properties of the material studied are presented in a table. Tensile strengths vary from 55 kg/mm<sup>2</sup> for the steel to 105-120 kg/mm<sup>2</sup> for the titanium alloy. Fatigue testing was performing in bending with rotation at a loading frequency of 2,800 cycles per minute at room temperature. Crack growth rates were found to decrease with increasing crack length. This was especially true of the titanium alloy. An area is found in the diagrams of fatigue crack growth rate as a function of stress intensity factor and crack length in which the rate is independent of length, corresponding to conditions of self-similarity of fracture. Equations are presented for calculation of the entire spectrum of stress intensity factor. References 16: 7 Russian, 9 Western.

USSR

UDC 669.293.5'293,784

INFLUENCE OF PRELIMINARY LOADING ON THE STRENGTH OF ELN-1 ALLOY

L'vov FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 13, No 4, Jul/Aug 77 pp 39-42 manuscript received 24 May 76

MAKSIMOVICH, G. G., LYUTYY, YE. M., SINCHENKO, N. M., DROZD, N. P., KUDLAK, S. M. and KISSIL', A. YE., Institute of Physico-Mechanics, Academy of Sciences Ukr SSR, L'vov

[Abstract] A study is made of the influence of stress and holding under preliminary load on the high temperature strength of the ELN-1 dispersion-hardened alloy which is based on niobium alloy with 1% zirconium and 0.1% carbon. All tests were performed on flat microspecimens with 3 mm<sup>2</sup> cross section, using metal of a single batch. The specimens were cut in the direction of rolling, then annealed at 1400°C in a vacuum of  $5 \cdot 10^{-6}$  mm Hg for 2 hours. With stress and preliminary loading at 900°C, the greater the level of deformation and the longer the exposure, the greater the increase in tensile strength and yield point. At 1100°C, the mechanical properties were stable. The strength characteristics of the specimens held under load at both temperatures decrease after testing at 1000°C in technical argon as the holding time increases from 100-1000 hours. Figures 3; references 6: all Russian.

USSR

UDC 539.2

INFLUENCE OF BORON ON THE FORMATION OF THE STRUCTURE OF HIGH-MODULUS CARBON FIBERS

Riga MEKHANIKA POLIMEROV in Russian No 3, May/Jun 77 pp 533-535 manuscript received 5 May 76

FIALKOV, A. S., MIKHAYLOVA, V. A., POLYAKOVA, N. V., GURVITS, YE. D., BONDARENKO, N. V., SHASHKOVA, T. N. and SAVOST'YANOVA, N. A., All-Union Scientific Research and Planning-Technological Institute for Electrocarbon Products, Moscow

[Abstract] The influence of the addition of boron and heat treatment temperature on the structure and properties of carbon fibers is studied. Objects of the study were unalloyed and boron-alloyed carbon fibers obtained by heat treatment consisting of isothermal heating of homopolymers of polyacrylonitrile fiber formed by the dimethylformamide method in the 2,100-2,800°C interval. Boron was introduced to the carbon fiber by

diffusion from the gas phase during heat treatment. The boron-containing additive used was borax. The fiber structure was studied on a JSM-2 scanning electron microscope, a URS-50 IM diffractometer in  $\text{CuK}_\alpha$  radiation filtered with nickel to determine the degree of graphitization. The boron content was determined by a spectral method on an ISP-28 spectrograph, the dynamic modulus on a UKB-1m defectoscope. The results indicate deep transformations in the internal structure of the carbon fiber as it is alloyed with boron. The introduction of boron significantly changes the electron structure. The curves of diamagnetic susceptibility of borided fibers are much lower on graphs than those of nonborided fibers. If boron content is high enough, diamagnetism is no longer temperature-dependent. Figures 3; references 8: 2 Russian, 6 Western.

USSR

UDC 539.2:678.01

#### ABSORPTION OF LIGHT AND THE DEVELOPMENT OF A LASER CRACK

Riga MEKHANIKA POLIMEROV in Russian No 3, May/Jun 77 pp 409-412 manuscript received 26 Jul 75

VUNTSEVICH, I. L., MUL'CHENKO, B. F., PILIPETSKIY, N. V. and SUPONIN, V. I., Institute of Problems of Mechanics, Academy of Sciences USSR, Moscow

[Abstract] A study is made of the absorption of light by the walls of a crack and the gas layer between them when specimens of polymethylmethacrylate transparent polymer are exposed to powerful laser pulses. The gray color of the laser crack produced in PMMA (as well as the black crack produced in polystyrene) results from particles of carbon black adhering to the walls of the crack. Additional electron microscope experiments are required to determine the dimensions of the carbon black particles. The absorption factor can be determined by taking into account these data and the results of the present article. The absorption index of the 30-100  $\mu\text{m}$  layer of gas between the crack walls is about  $20 \text{ cm}^{-1}$ , 1,000 times less than that of graphite but approximately 1,000 times greater than that of the ordinary block polymer. The energy of the laser beam is absorbed due to "self-induced" nontransparency caused by the presence of the carbon black leading to an increase in the mass of the gas wedge, an increase in pressure and as a result, crack growth. Figures 2; references 5: all Russian.



USSR

UDC 678.5:622.992.2:620.17

LOAD-BEARING CAPACITY OF PIPES MADE OF REINFORCED PLASTICS SEALED WITH FILMS

Kiev PROBLEMY PROCHNOSTI in Russian No 9 (99), Sep 77 pp 15-20 manuscript received 10 Nov 76

ZAYTSEV, G. P. and SUD'IN, V. N., Moscow Institute of Aviation Technology

[Abstract] An analysis is made of the problem of estimating the strength of frp sealed with polymer films and the influence of macrodefects in the material on the load-bearing capacity of pipe under static loading conditions. The object studied consisted of frp pipe based on type VM-1 reinforcing glass fiber and EDT-10 binder, produced by longitudinal and transverse winding of threads on a cylindrical mandrel at a ratio of longitudinal to transverse layers of 1:2. Each layer was sealed with a barrier layer of polymer film of 2 types: polyethylenephthalate and epoxy fluoroplastic. A strength criterion was developed for evaluating the load-bearing capacity of this type of pipe. The method suggested was used to determine specific surface energy of failure and the stress intensity coefficients which depend essentially on the location of cracks in relationship to the primary direction of reinforcing material. A method is suggested for calculating the critical failure stress and the strength reserve factor of pipe of this type under static loading with internal pressure. The method considers the influence of defects in the material. The authors thank academician S. V. Serensen (deceased) for his guidance regarding this work. Figures 4; references 9: 8 Russian, 1 Western.

USSR

UDC 669.14.018.44:539

ON THE PROBLEM OF ESTIMATING AND PREDICTING THE STATISTICS OF LONG-TERM STRENGTH CHARACTERISTICS OF HEAT RESISTANT METALLIC MATERIALS

Kiev PROBLEMY PROCHNOSTI in Russian No 7 (97), Jul 77 pp 49-57 manuscript received 10 Nov 76

KOVPAK, V. I., Institute of Strength Problems, Academy of Sciences Ukr SSR

[Abstract] Experimental data are available on the long-term strength of various materials, allowing the problem of estimating and predicting the statistics of long-term strength characteristics to be approached with some confidence. The present work presents results of studies intended

to establish the regularities of the change in the statistical characteristics of long-term strength as a function of stress and temperature. Recommendations are presented on the estimation and prediction of the statistics of long-term strength with dispersion of experimental data within and between melts. The main statistical characteristic analyzed is the dispersion, the values of which decrease with decreasing stress level in comparison to their values during fatigue testing, then increase upon extremely long-term testing to failure. Estimation of the statistical characteristics of variations in experimental data between melts on the basis of the method of summary diagrams is found to reflect the actual physical nature of the kinetics of the characteristics and their statistics with respect to time to failure and stress, and also to allow prediction of statistics similar to the prediction of mean values of long-term strength characteristics with dispersions within and between melts. Figures 5; references 16: 12 Russian, 4 Western.

USSR

UDC 678.5:539.1

ON THE QUESTION OF THE MAXIMUM EQUILIBRIUM OF PLATES AND SOLIDS MADE FROM BRITTLE ORTHOTROPIC MATERIALS WITH CRACKS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 74-79 manuscript received 10 Nov 76

ZAYTSEV, G. P., Moscow Aviation Technology Institute

[Abstract] The strain of an orthotropic plane element with a central crack (notch) and a solid orthotropic prism with a central crack in the form of a ring was investigated to determine the maximum stress these objects could withstand under a one-time static load. The mathematics of the study are presented which yielded an equation for calculating the maximum stress in the brittle orthotropic materials. The effect of anisotropy on maximum stress can be determined both from the magnitude of tensile strength of a defect-free material, depending on direction, and from the magnitude of the maximum radius of a flat circular internal crack which does not affect the strength of the solid. The values of critical stress do not depend on a circular crack if its radius is less than the maximum radius stated above. Experimental data obtained in testing samples of epoxyphenol reinforced plastics were well described by the equation obtained. The maximum radii of circular cracks were determined for 27-63S and EF-32-301 glass plastics and found to be 0.496 and 0.359 mm, respectively. The authors thank S. V. SERENSEN (deceased), Academician of the Academy of Sciences Ukrainian SSR, and V. V. PANASYUK, corresponding member of the Academy of Sciences Ukrainian SSR, for their suggestions and assistance. Figures 4; references 9: 8 Russian, 1 Western.

## STUDY OF THE FATIGUE FAILURE OF HEAT-RESISTANT ALLOYS UNDER CONDITIONS OF HIGH-TEMPERATURE STEADY- AND NONSTEADY-STATE LOADS

Kiev PROBLEMY PROCHNOSTI in Russian No 8, Aug 77 pp 30-33 manuscript received 9 Jun 76

KUFAYEV, V. N., PALIYENKO, YE. YA., and POGREBNYAK, A. D., Institute of Mechanics, Academy of Sciences Ukr SSR

[Abstract] A detailed analysis was made of the fatigue of EI867, EI617 and ZhS6K heat-resistant alloys under high-temperature steady- and nonsteady-state loads at elevated temperatures (600-950°C). Fatigue tests of EI867 alloy at room temperature show that grain-boundary microhardness remains high due to the precipitation of carbides, while the grain-body microhardness drops off very early in the tests. At 600°C grain-boundary microhardness remains fairly constant, being preserved by precipitation of a strengthening gamma-prime phase. At 700°C precipitating particles increase microhardness of both grain body and boundary to overcome the weakening effect of cyclic stresses. At 800°C microhardness of grain body and boundary increases due to an increase in the amount of excess phases and their coalescence, with maximum microhardness occurring at  $2 \cdot 10^7$  cycles, promoted by precipitation hardening processes. Also, self-diffusion intensification leads to a partial welding of defects, and strengthening and damaging processes are mutually equalized. Microhardness measurements and fracture analysis of EI867 at 600-800°C showed that crack nucleation and development were promoted by shear strains in the grain body, causing intragranular fracture while the intergranular structure of the alloy kept fatigue strength high. Results similar to those described above was found for EI617 strain-hardened alloy and ZhS6K cast alloy. Figures 4; references 6: all Russian.